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STRENGTHENING THE THREE-HINGED ARCH BRIDGE OVER THE MISSISSIPPI RIVER BETWEEN MINNEAPOLIS AND ST. PAUL, MINN.

By FRANK H. CONSTANT.*

The three-hinged arch bridge over the Mississippi River on the line of Lake St., Minneapolis and Marshall Ave., St. Paul, was built originally in 1888, jointly by Hennepin and Ramsay counties as an ordinary highway bridge. Mr. J. S. Sewall, of St. Paul, was the engineer. The bridge crosses a very picturesque part of the Mississippi River, and now forms a connecting link between the riverside parkway systems of the Twin Cities. The total length of the bridge is 1,271 ft., comprising two 456-ft. three-hinged arch spans, three high towers, two approach spans of 133 ft. and 95 ft., respectively, and four panels of trestle approach. The 456-ft. spans are, so far as the writer is aware, the longest three-hinged arch spans in the country. The structure is a deck bridge, with floor about 120 ft. above the bed of the river. It was designed to have an 18-ft. central roadway and two 6-ft. sidewalks, and to carry the following live loads:

Floor system: 100 lbs. per sq. ft., or 10 tons on a width of 4 ft.
Trusses:
Approach spans, 1,500 lbs. per lin. ft. per truss.
Arch spans, 1,000 lbs. per lin. ft. per truss.

All material was wrought-iron. Members were proportioned for the following unit-stresses:

	Lbs. per sq. in.
Bottom chord of arch	13,000
Top chord of arch	10,000
Posts and diagonals of arch	10,000
All other compression members	12,000
[All compression unit-stresses were reduced by formula.]	
Laterals (tension)—	
Eyebars	15,000
Plates and shapes	12,000
All other tension members—	
Eyebars	12,000
Plates and shapes	10,000
Floorbeams, lower flange	12,000
Shop rivets and pins—	
Shear	9,000
Bearing	15,000
Bending	15,000

No metal less than 5-16-in. thick was used. The bridge cost about $150,000.

The form and arrangement of the old structure may be obtained from the drawings Figs. 1 and 2. In the side elevation in Fig. 1, the outline of the old arch trusses is given by broken lines (the full lines indicating the new work); the towers and approach spans are of the same outline in old and new work, and their original state is, therefore, correctly represented by the full lines. The plan in Fig. 1 shows the position of the old and new parts after reconstruction, and is deceptive as to the condition of the original structure. However, reference to the cross-sections in Fig. 2 and some of the sections in Fig. 3 will give the necessary data. The arch trusses were set 29 ft. apart, in vertical planes, and the trusses of the approach spans were 17 ft. 6 ins. apart c. to c.

For many years the traffic over the bridge was light and purely suburban. In 1905 the Twin City Rapid Transit Company, which operates the street railways of Minneapolis and St. Paul, desiring to build a new interurban line between the two cities on Lake street, secured permission to rebuild and strengthen this bridge sufficiently to accommodate interurban cars on double track. This work involved widening the existing roadway and reinforcing the structure to carry the following live loads:

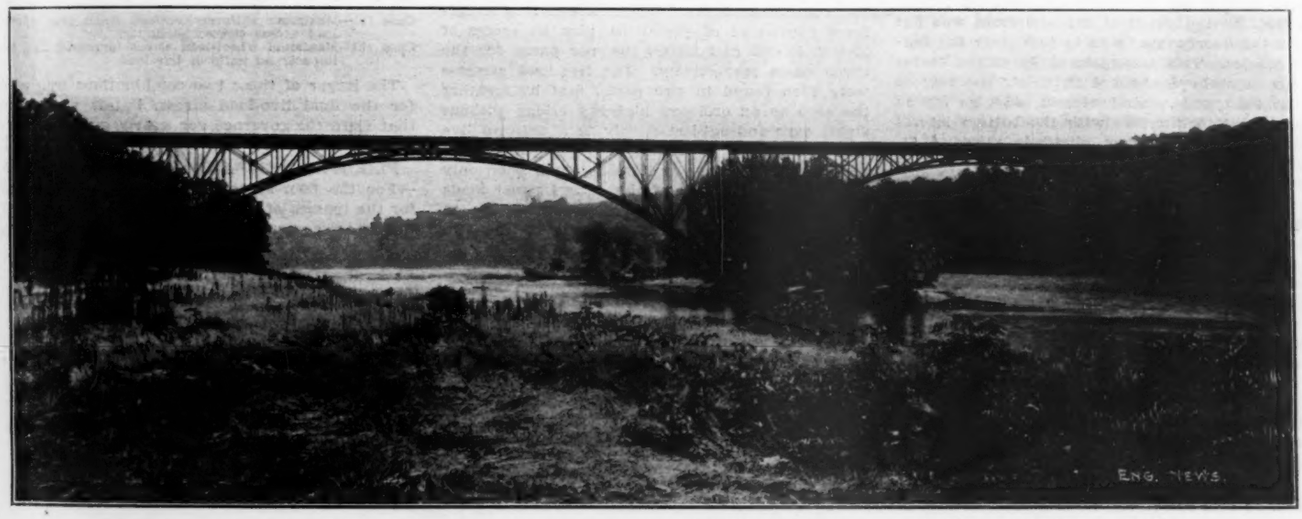
Wheel-loads:
Case I.—Three 36-ton, double-truck cars 45 ft. long on each track; 18,000 lbs. per axle; truck wheel-base 5 ft., c. to c. of trucks 22 ft.
Case II.—Two 40-ton, double-truck cars 45 ft. long on each track; 20,000 lbs. per axle; truck wheel-base 5 ft., c. to c. of trucks 22 ft.
Case III.—One 40-ton, double-truck car 45 ft. long on each track; 20,000 lbs. per axle; truck wheel-base 5 ft., c. to c. of trucks 22 ft.

Together with the following
Distributed Loads:
Floor System.—100 lbs. per sq. ft. of roadway on the portion not covered with cars.
Sidewalks.—80 lbs. per sq. ft.
Approach Trusses.—100 lbs. per sq. ft. of roadway on the portion not covered with cars.
Arch Trusses.—90 lbs. per sq. ft. of roadway on the portion not covered with cars.

The roadway was widened from 18 ft. to 33 ft. to allow for two street-car tracks 10 ft. c. to c., with two 6-ft. sidewalks outside the roadway as before. A third (middle) truss was added to all spans, and the floor beams were strengthened where necessary, to transmit the increased loads. A middle leg was added to each bent of each of the towers. The reconstructed bridge is shown in outline in Fig. 1 and in cross-section in Figs. 2 and 3. In the first the new work is represented by full lines and the old work by heavy broken lines. In Figs. 2 and 3 the sections in full lines show the work *as reconstructed*, while the sections drawn in broken lines represent the old bridge.

The general scheme of the reconstruction is as follows:

APPROACH SPANS.—The old approach trusses and trestle posts were originally 17 ft. 6 ins. c. to c., with cantilever sidewalk brackets riveted on the outside. The floorbeams and lateral bracing were disconnected and the trusses and posts, with sidewalk brackets attached, were moved out to 32 ft. 6 ins. c. to c. A new and



GENERAL VIEW OF LAKE ST. AND MARSHALL AVE. BRIDGE OVER MISSISSIPPI RIVER, AFTER RECONSTRUCTION.

[The new (middle) arch-truss has the same span as the old (outside) arch-trusses, but its bottom chord is 5 ft. 9 ins. lower at the crown and 4 ft. higher at the end-pins, producing the appearance shown in the view.]

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stronger truss of the same general dimensions as the old was placed in the center line of the bridge between them. The old floor beams and lateral bracing were shortened and replaced between the trusses, new pieces being constructed to supply the deficiency. Fig. 2 shows the old and new arrangements of the roadway.

ARCH SPANS.—Owing to the great height of the bridge above the river, it was uneconomical to use false work for the arches in reconstruction. The old arch trusses were therefore left untouched in their position of 29 ft. c. to c., the increase in width of roadway being accomplished by putting the sidewalks on new cantilever brackets outside of the trusses (Fig. 2). To care for the increased loading, a new truss of the same type as the old, but stronger and heavier, was put in at the center of the bridge. In order not to disturb the old floorbeams and top lateral bracing, the top chord of the new truss was put below the floorbeams so as to just clear the bottom flanges. This arrangement drops the center of the new chord about 4 ft. below the centers of the old chords. Similarly, in order so far as possible not to interfere with the bottom lateral system, the new bottom chord is raised 4 ft. above the old chords at the abutments, remains above and clears the bottom lateral bracing for six panels, and then intersects and gradually drops below the lateral system until at the center it is 5 ft. 9 ins. below the old chords. The view on the preceding page, showing the bridge as a whole, exhibits the general appearance after reconstruction, while the view Fig. 7 shows the arrangement at the shoes. The dropping of the new arch chord below the old arch curve was necessary to obtain the requisite truss depth, the curve chosen being the outcome of several trial designs. It is the general opinion that the beauty of the bridge has not been appreciably marred by this arrangement.

FLOOR SYSTEM FOR ARCH SPANS.—The old wooden flooring and joists were entirely replaced, as best shown by the cross-section Fig. 2, and new steel track stringers were put in under the rails. The old floor beams with the additional support obtained by the center truss were found to be strong enough to carry the new loads. New stiffeners were riveted to their webs under the track stringers and over the bearing points on the center truss, and a few additional flange rivets were put in near the center to take care of the increased flange increment at that point. Sidewalk brackets were provided for the arch spans.

TOWERS, WITH BRACING.—The old tower posts were left in their original shape, but in addition to the new center posts, new stiff transverse and longitudinal bracing was provided. (See Fig. 3.)

FOUNDATIONS.—Enough of the old stone foundation was removed and replaced with concrete to give the shoes for the new center truss a sufficiently strong bearing. Fig. 4 gives the details of the reconstruction together with magnitudes and directions of reactions.

STRESSES AND UNIT STRESSES.

ARCHES.—The live load stresses in the arch trusses were obtained in the following manner: A table of coefficients was constructed giving the stresses in every member of the half span produced by a unit load of 1,000 lbs. placed successively at each point, from 1 to 24. As stated in a preceding paragraph the live-load consisted of one of three cases of wheel-loads together with a uniform load of 60 lbs. per sq. ft. on portions of the roadway not covered with cars. These concentrated and uniform loadings were then found to be equivalent to the following panel-loads upon the middle truss, considering the floor beams to act as continuous girders over the three trusses:

Concentrated Live Panel Loads:
Case I.—48,000 lbs. per panel, on 7 panel points.
Case II.—51,000 lbs. per panel, on 5 panel points.
Case III.—57,000 lbs. per panel, on 2 panel points.
Uniform Live Panel Load:
19,000 lbs. per panel.

It was found convenient to consider each of the concentrated panel-loads as equal to a uniform panel-load of 19,000 lbs. plus an excess of 29,000, 32,000 and 38,000 lbs. per panel for the three cases respectively. The live-load stresses were then found in two parts, first by treating the arch as an ordinary highway bridge without street cars and subjected only to a uniform live load amounting to 19,000 lbs. per panel; and secondly, by considering it to be acted upon only by Cases I, II or III of the excess panel loads placed at such consecutive panel points as to produce maximum effects, the sum of the two stresses thus obtained being the total live-load stress. The table of coefficient stresses referred to above showed at a glance which panel points must be loaded to produce a maximum tension or compression in any member. For example, if it was found from the table that loads at, say, nine consecutive points produce compression in a given member, the sum of the nine corresponding coefficient stresses multiplied by 19 gave the maximum uniform live-load compression. Again, by placing 7 excess panel loads [illegible] lbs. each, or 5 of 32,000 lbs., or 2 of 38[illegible] lbs. over the consecutive points producing [illegible]mum effects and noting which case furnis[illegible] the largest sum, the maximum compressi[illegible]ress from the excess loading was obtained. T[illegible]m of the uniform and excess stresses gave [illegible] total live-load compression. The tension w[illegible]ound in a similar manner by using the rema[illegible]g 15 panels and the corresponding coefficie[illegible] No

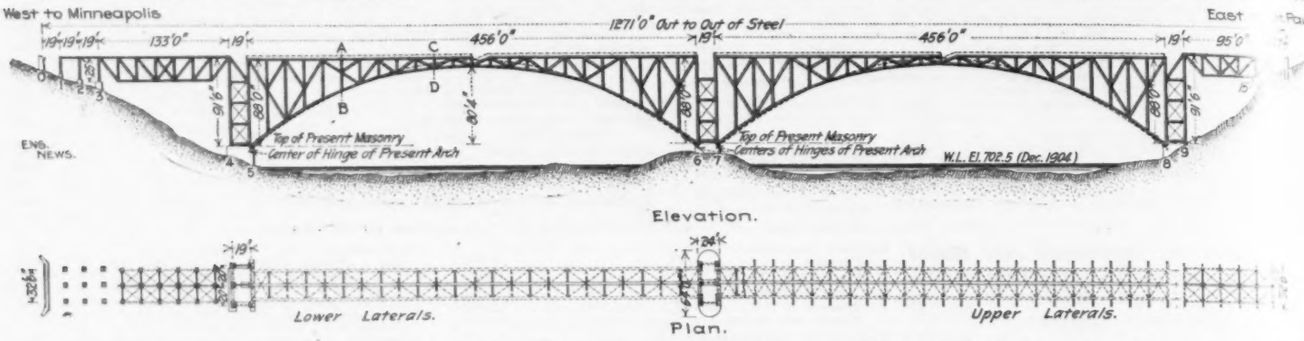


FIG. 1. GENERAL ELEVATION AND PLAN OF STEEL ARCH BRIDGE OVER MISSISSIPPI RIVER BETWEEN ST. PAUL AND MINNEAPOLIS, AFTER RECONSTRUCTION.

(New material is indicated by full lines, old material by broken lines.)

It was found convenient to consider each of the concentrated panel-loads as equal to a uniform panel-load of 19,000 lbs. plus an excess of 29,000, 32,000 and 38,000 lbs. per panel for the three cases respectively. The live-load stresses were then found in two parts, first by treating the arch as an ordinary highway bridge without street cars and subjected only to a uniform live load amounting to 19,000 lbs. per panel; and secondly, by considering it to be acted upon only by Cases I, II or III of the excess panel loads placed at such consecutive panel points as to produce maximum effects, the sum of the two stresses thus obtained being the total live-load stress. The table of coefficient stresses referred to above showed at a glance which panel points must be loaded to produce a maximum tension or compression in any member. For example, if it was found from the table that loads at, say, nine consecutive points produce compression in a given member, the sum of the nine corresponding coefficient stresses multiplied by 19 gave the maximum uniform live-load compression. Again, by placing 7 excess panel loads [illegible] lbs. each, or 5 of 32,000 lbs., or 2 of 38[illegible] lbs. over the consecutive points producing [illegible]mum effects and noting which case furnis[illegible] the largest sum, the maximum compressi[illegible]ress from the excess loading was obtained. T[illegible]m of the uniform and excess stresses gave [illegible] total live-load compression. The tension w[illegible]ound in a similar manner by using the rema[illegible]g 15 panels and the corresponding coefficie[illegible] No

impact was added to the stresses obtained in this way.

The live-load stresses from the wheel loads alone with no uniform load on the bridge were likewise obtained, in a manner similar to the excess stresses noted above, and the concentrated live-load stresses thus obtained were increased 25% for impact. The two combinations were then as follows:

Case (a)—Maximum uniform live-load stress plus wheel-load excess stress; no impact.
Case (b)—Maximum wheel-load stress increased 25% for impact; no uniform live-load.

The larger of these two combinations was used for the final live-load stress, but it was found that Case (b) governed for nearly every member of the arch truss.

FLOOR-SYSTEM AND APPROACH SPANS.—For the floor-system of the whole bridge and for the trusses of the approach spans, the sum of the stresses resulting from the uniform loading and the maximum wheel-load case was increased 25% for impact.

In determining the proportion of floor and live loads going to outer or inner arch trusses, the floor-beams were considered to be continuous girders with three points of support. The reasonableness of this assumption is discussed in a subsequent paragraph under deflections.

The following unit stresses were used in proportioning the parts:

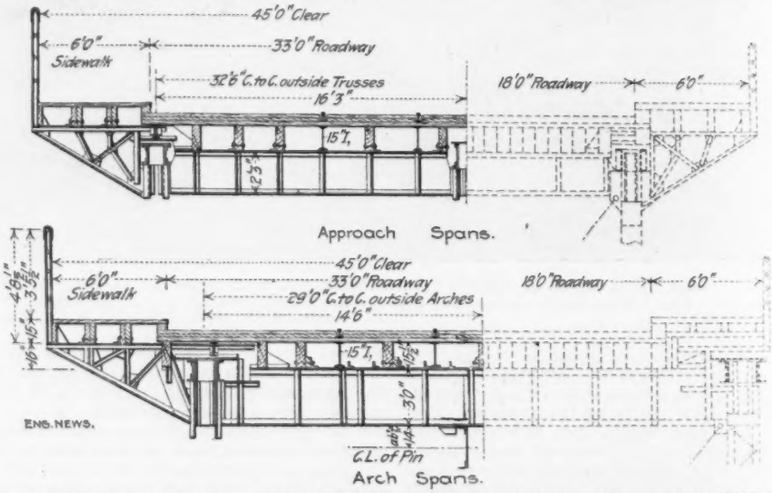


FIG. 2. COMPARATIVE SECTIONS OF ROADWAY, SHOWING OLD AND NEW DIMENSIONS LAKE-MARSHALL AVE. BRIDGE.

(Old section shown in broken lines. Reconstructed section shown in full lines without distinction between old and new material.)

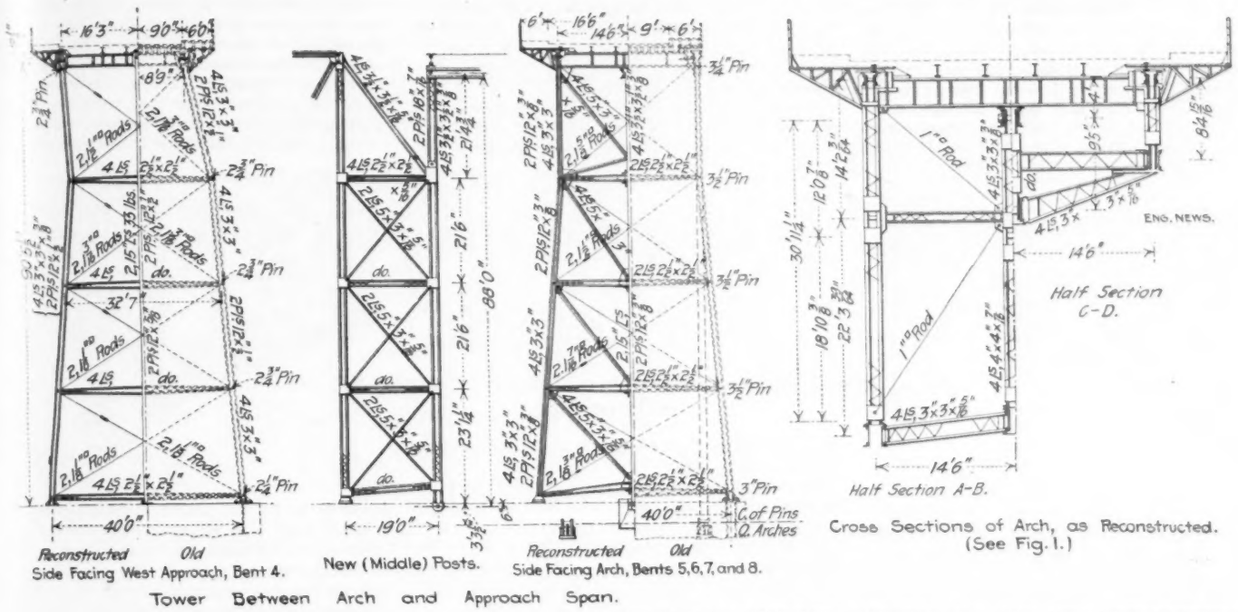
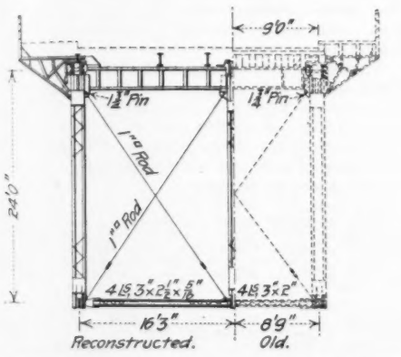
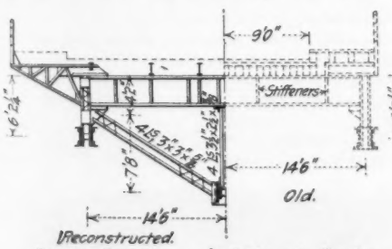

Reconstructed Old
Side Facing West Approach, Bent 4.
New (Middle) Posts.
Reconstructed Old
Side Facing Arch, Bents 5,6,7, and 8.
Tower Between Arch and Approach Span.
Half Section C-D.
Half Section A-B.
Cross Sections of Arch, as Reconstructed.
(See Fig. 1.)

FIG. 3. COMPARATIVE CROSS-SECTIONS, SHOWING OLD AND NEW ARRANGEMENT OF ARCH AND APPROACH TRUSSES, BRACING, TOWERS, ETC.





Arch spans:	Tension	15,000 lbs.	per sq. in.
	Compression	15,000 "	(reduced by formula)
Rivets and pins—shear		10,000 "	medium steel
		9,000 "	soft steel
Bearing		20,000 "	medium steel
		18,000 "	soft steel
Bending		20,000 "	medium steel

Approach Spans: American Bridge Co. specifications for highway bridges (1901).

Reversal of stress, after the dead-load had been combined with the live-load stresses, was provided for by adding half of the lesser to each of the pair of alternate stresses, and designing the member by the above units for both of the augmented stresses. The stress sheet, Fig. 5, gives the dead-load and live-load [Case (a) or (b)] stresses and the final results after being corrected for reversal, as well as the sections of the new (center) arch trusses. It will be noticed that all members of the arch truss are subject to stress-reversal except the lower chord and a few vertical posts whose sole duties are either to support floor-beams or to prevent the lower chord from changing its shape.

The design is pin-connected, similar to the old one, although, as said, the new trusses are much heavier than the old.

ERECTION.—The erection of the new work required for the widening of the bridge was begun in Oct., 1905, and continued throughout the winter, being completed in May, 1906. During that time many difficulties were met and overcome, and it is a notable fact that there was not a single serious accident either to workmen or material, although the work was carried on in all kinds of weather.

Erection was started on the east or St. Paul end of the bridge and consisted in widening the 95-ft. span from 19 ft. to 32 ft. 6 ins. c. to c. trusses. Three heavy timber bents were constructed under these trusses; the old floorbeams, bottom struts, top and bottom laterals and sway rods were taken out and as fast as removed were loaded on wagons and sent back to the shops, about two miles from the site, for rebuilding. As the old material was taken out, the new center truss was erected and supported on the timber bents together with the old trusses. While the old beams and laterals were being remodeled, the contractor was kept busy erecting the new material for the first tower and drilling holes and fitting stiffeners to the floorbeams in the two arch spans. When the old material, rebuilt, began to arrive, the old 95-ft. trusses were moved out on the timber bents to their new position. The new top sections of the columns in the towers supporting these trusses were then erected and connected with the trusses and the whole braced. The new and old floorbeams, struts, etc., were put in, stringers laid and the entire span made ready for the timber decking.

The 133-ft. span on the west or Minneapolis end was then erected in the same manner, thus practically completing the two ends of the bridge. The erection of the center tower followed and the whole structure was made ready to receive the arch trusses.

Piles were driven in the river directly beneath points 3 near each end of each arch and a heavy timber bent built on them, in each case well blocked and wedged under the old trusses to support partly the bridge while the new trusses were being erected. The old decking was entirely removed and the new I-beam stringers laid across the entire bridge, but placing the two outside stringers within the inside stringers, as shown in the sketch Fig. 6, so as to make two double I-beam girders in each panel. These were used to support the center trusses during erec-

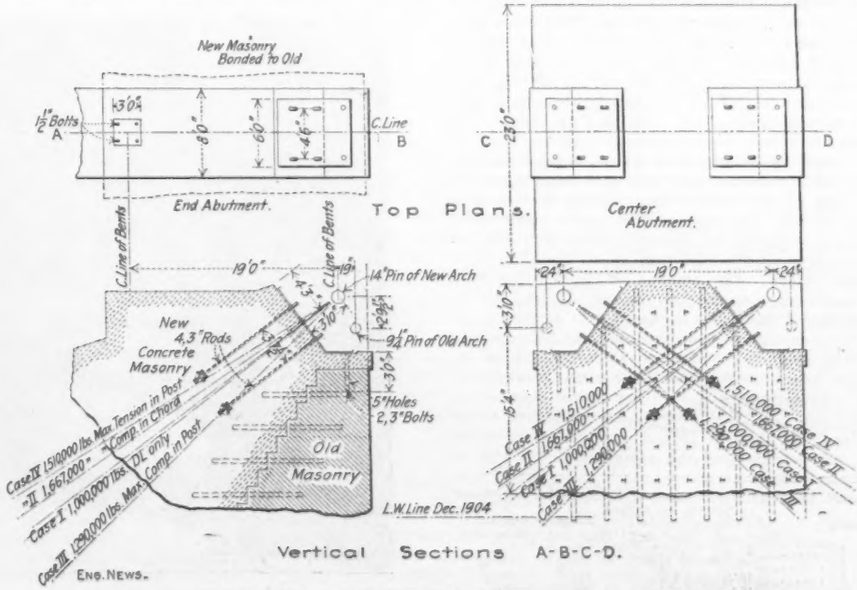


FIG. 4. DETAILS OF CONCRETE ABUTMENTS FOR NEW ARCH TRUSS.

tion, as shown in the sketch Fig. 6. The top chords of the arch trusses were erected first and were temporarily well bolted to each floorbeam to prevent subsequent creeping toward the center. Large U-bolts 2⅜ ins. in diameter were used in the center of each panel to support the trusses, as shown in Fig. 6. The trusses were then erected complete to point 11 in each of the four half arches. Where the line of the bottom chord of the new arch crossed the line of the bottom chord of the old arches, the lateral bracing was removed a panel at a time in each half arch, sent back to the shop and rebuilt to fit the new conditions. Measurements were then taken between the centers of pins at points 11 in the bottom chords and points 12 in the top chords, and the lengths of the arch members between these points were computed from these measurements. While these members were being fabricated in the shop, the new bottom struts required to give lateral support for the center truss bottom chord, as indicated in cross sections, Fig. 3, were put in and everything made ready to swing the arches on the arrival of the center members. Brackets were bolted to the bottoms of the floorbeams on each side of the new top chord to prevent the buckling of that member when the trusses should be finally swung, and one end of each of the new struts in the bottom lateral system was left loose to allow free motion, in a vertical direction, of the new trusses. The center members finally arrived and the center pin at point 13 was driven in about 40 minutes in each span. The bolts through the bottom flanges of the floorbeams and top flanges of the new top chords were taken out, the U-bolts slacked off and the new trusses made to support their own weight.

As soon as the old arches were relieved of the weight of the new truss, they deflected negatively and the center truss positively, thereby increasing the clear distance between the bottom flange of the floorbeams and the top chord of new arch by the sum of these deflections. This clear space was carefully measured at each point with a pair of calipers. At this time the deck of the bridge was entirely stripped except for the steel track stringers and a few old wooden joists used as a temporary floor. All of this weight was carried, of course, by the old trusses. In order to make the center truss carry its share of the weight of the steel stringers and floorbeams and of any future decking and loading placed upon the bridge, the calipered distance under each floorbeam had to be slightly increased by the use of jacks and the resulting space filled up with shim plates. The amount of jacking required at each floor beam was readily determined by the use of Table II, in which the deflections at every panel point are computed for both trusses under equal unit loads of 1,000 lbs. placed at every panel point. The approximate weight to be transferred to the center truss was about 4,000 lbs. per panel, and the corresponding relief to each of the old trusses was therefore 2,000 lbs. By multiplying the computed deflections of the table by 4 and 2, respectively, and adding to the calipered distances, the required thicknesses of shim plates were obtained. Table I. gives the average thicknesses for a few corresponding points at each end of each span.

TABLE I.—Average Thickness of Shim Plates at Panels Named, in Inches.

Panel No.	East arch—East end.	East arch—West end.	West arch—East end.	West arch—West end.
1	0	1/4	11/32	1/4
4	3/8	7/8	7/16	27/32
7	1 3/16	1 1/16	1 1/16	1 9/16
10	27/16	27/16	21/32	2 5/8
13	3 5/8	...	4 15/32	...

After jacking and shimming, the riveting of the bottom lateral struts and all other steel parts was completed, the new work painted, the wooden floor laid, and the bridge put into service about June 1, 1906.

The erection was done by Frankman Bros. & Morris, of St. Paul, Minn., who used an ordinary flat car, weighted, on which were mounted a derrick and an engine and boiler. The rear trucks were geared to the engine so that the car was self-propelling. There was no false work used other than that noted heretofore, except, of course, necessary staging for rivet gangs. An air compressor was located on the island at the foot of the center tower, which supplied the power for the pneumatic drills and riveters used throughout the work.

Several test pieces cut from various parts of the old arches indicated that the old material was practically unimpaired.

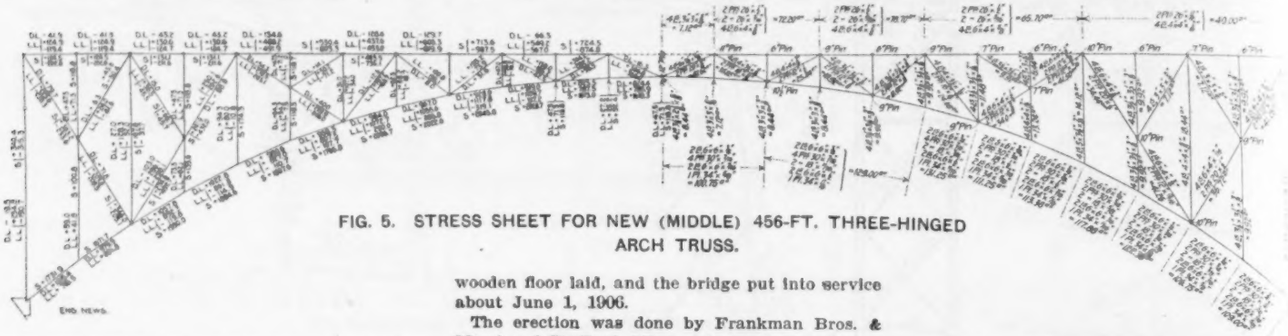


FIG. 5. STRESS SHEET FOR NEW (MIDDLE) 456-FT. THREE-HINGED ARCH TRUSS.

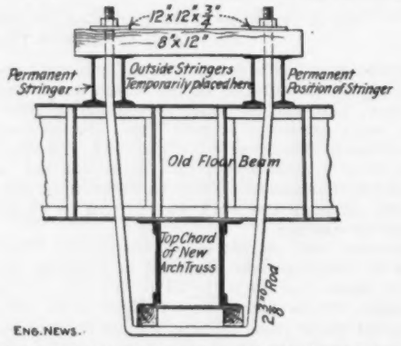


Fig. 6. Sketch of Temporary Stirrup Suspension of Top Chord of New Arch.

DEFLECTIONS.—It must be quite evident from the nature of the work above described that the subject of relative deflections would arise in many different forms. In the beginning nothing was known about the old arches except what could be gathered from an incomplete set of working drawings or from actual measurements in the field. The computed center camber was found to be 7½ ins. and the deflection under the original dead load about 3 ins. Correcting for temperature changes and comparing with two sets of survey notes made the preceding winter and spring the computed elevations were found to check very closely with those of the surveys. The exact position of the old trusses in space was thus definitely established and the dimensions of the new truss could be fixed with some degree of certainty that they would correspond with the old. The top chord of the center truss was given a theoretical clearance of ¾-in. under the first floorbeam and a camber of 6¾ ins. at the center. The computed deflections of new and old trusses under various conditions are as follows:

	Ins.
Center Truss:	
Deflection at center under full dead load	4.90
Deflection at point 7 under full dead load	1.04
Deflection at center under three 36-ton cars on each track covering panels 10 to 16, inclusive	4.81
Deflection at center due to range of temperature of 100° F.	5.82
Outer Truss:	
Deflection at center under full dead load	2.90
Deflection at point 7 under full dead load	0.79
Deflection at center due to range of temperature of 100° F.	5.40

These are, of course, the deflections which would occur if the three trusses could act independently. It has been said above that the floorbeams are continuous girders. They are, moreover, very stiff, not permitting unequal deflections of the three trusses of more than ⅛ or ¼ in.

The question of what proportion of the loading each truss takes could not be avoided alto-

FIG. 7. VIEW OF ONE OF THE ABUTMENTS OF 456-FT. THREE-HINGED ARCH.

gether. This same problem arises in every three truss bridge when the floorbeams are continuous or rigidly riveted to center truss, but it becomes more noticeable where the spans are so long and the deflections so great. The design was adopted and work well under way before the matter could be given theoretical attention. The results, therefore, are confirmatory of the practical judgment of the designers. The loading to come upon the bridge after the shimming was completed was the weight of the wooden floor, the uniform live load, and the concentrated loads due to the street cars. The deflections at points 4, 7, 10 and 13 were computed for both old and new trusses; first, for 1,000 lbs. placed at every panel point; second, for 1,000 lbs. placed only at the point for which the deflection is computed. The results are shown in Tables II and III, which also give the ratios of corresponding deflections for old and new trusses.

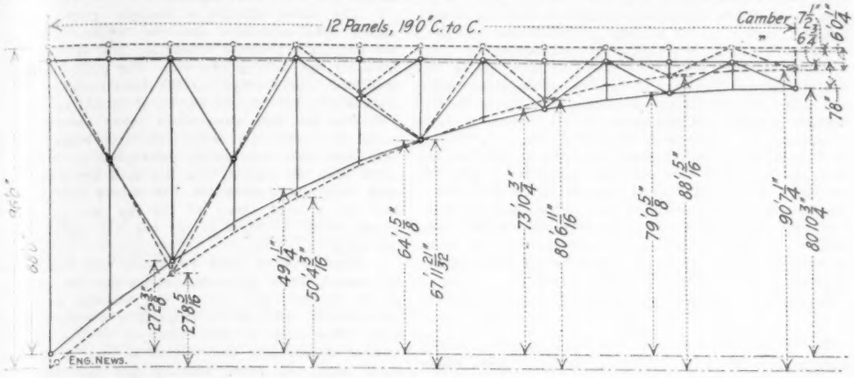


FIG. 8. DIAGRAM OF RELATIVE DEPTHS AND CAMBERS OF OLD AND NEW ARCH TRUSSES.

TABLE II.—Deflections Under Uniform Load. 1,000 lbs. at Every Panel Point.

Deflection at:	4	7	10	13
Outer truss	.0145	.0313	.0583	.1340
Center truss	.0070	.0214	.0509	.1036
Ratio = Deflection in O. T. / Deflection in C.T.	2.07	1.46	1.15	1.29
Average ratio		1.52		

TABLE III.—Deflections Under Concentrated Loads. 1,000 lbs. at Deflection Point Only.

Deflection at:	4	7	10	13
Outer truss	.0113	.0183	.0233	.0406
Center truss	.0050	.0080	.0119	.0178
Ratio = Deflection in O. T. / Deflection in C. T.	2.26	2.29	1.96	2.28
Average ratio		2.18		

In Table II the average ratio is 1.52; in Table III it is 2.18. These ratios, then, are the inverse measure of the relative rigidities of the two trusses for uniformly distributed or concentrated loading, respectively, and indicate the proportion of the loading which will be taken by center and outer trusses subsequent to the placing of the shim plates. But in designing the center truss, the loading was assumed to be distributed between the trusses by treating the floorbeams as continuous girders. This assumption gives the following ratios for the three classes of loading named above:

$$(a)\ \frac{\text{Weight of wooden floor going to center truss}}{\text{Weight of wooden floor going to outer truss}} = 1.55$$

$$(b)\ \frac{\text{Uniform live load going to center truss}}{\text{Uniform live load going to outer truss}} = 1.00$$

$$(c)\ \frac{\text{[Uniform live + wheel] panel load going to center truss}}{\text{[Uniform live + wheel] panel load going to outer truss}} = 2.15$$

Cases (a) and (b) should be compared with Table II. In the former the average ratio of actual distribution (1.52) checks almost exactly with the assumed (1.55); but in Case (b) it is found that the center truss will take more than the assumed amount. Case (b), however, is of no importance since the center truss was designed for the more than twice as large concentrated car loading and is amply strong for the rare condition of a uniform load extending from railing to railing and from end to end of span.

Case (c) for a single panel load checks almost exactly with the average for Table III. The maximum stresses in the members of the center truss generally occur, however, under several or many panel loads, so that the ratio of true distribution is intermediate between those of Tables II and III, probably about 2.00. Since this is smaller than the ratio in (c) the outer truss will get a slightly larger proportion of load than was assumed, and the center truss less.

Under the continuous girder assumption and with the uniform live load extending from railing to railing and with each track covered with the excess load for street car concentrations, the outer trusses each get 1,092 lbs. per lineal ft. They were originally designed for 1,000 lbs. per lineal ft. The new dead load on the old trusses is slightly less than formerly. Hence the new loading on the old trusses will probably never exceed the amount they were originally designed for.

The method here outlined is, of course, only an approximate solution of the problem of load distribution. A perfect solution would be much more complex and would involve the deflections, not only under the concentrated load, but at every other point of the bridge at the same time. Moreover, a number of different positions of the live load would have to be taken.

TEMPERATURE DEFLECTIONS.—The deflections above and below the normal of 65° F. are as follows:

	Point 7.	Point 13. (center.)
Temp. +115°F. Outer truss	= +1.50 ins.	= +2.70 ins.
Temp. +115°F. New truss	= +1.53 ins.	= +2.91 ins.
Temp. — 35°F. Outer truss	= —3.00 ins.	= —5.40 ins.
Temp. — 35°F. New truss	= —3.06 ins.	= —5.82 ins.

These differences are not enough to affect the stresses in the trusses. The shim plates were put in in April when the temperature was considerably below normal.

Bridge builders and engineers who have had experience in reconstructing old structures will appreciate the difficulties of design, detail, shopwork and erection encountered in this work. The Minneapolis Steel & Machinery Co. were the contractors and the work was built according to their design. The total weight of new steel was about 1,050 tons, and the total cost of the reconstruction, including foundations and wood flooring, nearly $100,000.

The work was executed under the general supervision of Mr. Geo. L. Wilson, Chief Engineer of the Twin City Rapid Transit Co., and the writer, who was Consulting Engineer for that company. Mr. Ralph Modjeski, Consulting Engineer, Chicago, had charge of the shop inspection.

THE WATER SUPPLY AND FIRE PROTECTION of Trenton, N. J., has been reported on by the Committee on Fire Prevention of the National Board of Fire Underwriters (135 William St., New York City). The committee states that the map of the distribution system should be corrected and brought up to date, and that complete records should be kept, especially of the daily water consumption and pressures and of the locations and types of all fire hydrants and gate valves. A number of 16 to 8-in. mains for reinforcing the distribution system are recommended. Improvements in the fire department, a revision of the building laws, and the employment of building inspectors, are advised. The report states that appointments in the water department are made wholly from political considerations, with results to be expected.

GRANITE-TOP MACADAM PAVING IN OAK PARK, ILL.*

By R. A. CARPENTER.†

Up to the year 1899, Oak Park had been striving to get a street pavement which would fill the conditions for a residence suburban town with regard to cost, general appearance, and durability. Prior to the above date, pavements had been constructed of limestone macadam, cedar block in the business district (which has since been displaced by brick), and two streets of asphalt. The limestone macadam streets were constructed with insufficient crown, and ground up rapidly under the action of traffic, and were exceedingly dusty if not properly sprinkled. Cedar-block pavement was expensive at almost any cost, and especially so at $1 per yd., when the life of the pavement will not exceed seven years and the abutting property is compelled to stand a second assessment to replace the old cedar blocks. Asphalt pavement, while desired by a few residents, did not meet with general approval from the fact of its being too expensive, and the possibility of becoming badly cracked in a very few years.

Under the above conditions, the first ordinance was drafted for paving Euclid Ave. from Chicago Ave. to Lake St. (2,200 ft.) with a granite-top macadam pavement. The roadway was paved to a width of 30 ft. between face of curbs and included the gutter flags. The curb and gutter was constructed on an 8-in. bed of cinders. The curb was 7 ins. thick, with an average height of 12 ins., and combined with a gutter flag 18 ins. wide and 6 ins. thick. The curb exposed at the summits of the gutter were 4 ins., and 8 ins. at the outlets of the gutters. The combined curb and gutter was constructed from Portland cement, fine granite screenings and crushed granite in proportions of 1:2:4. For 1 in. on top of gutter flag and roadway face of curb the facing was composed of 1:1 cement and fine granite screenings. The curb and gutter was laid in 6-ft. sections, and the corners were rounded to a radius of 6 ft. at street intersections and 18 ins. at public alleys.

The roadway between the gutter flags was excavated to such a depth and in such a manner that after the sub-grade had been thoroughly rolled with a steam roller of not less than ten tons weight, and after the different courses of material had been placed thereon, the finished pavement in the center of the roadway would be 6 ins. above the top of the curb, giving an average crown of 1 ft. in 30 ft. On the sub-grade the first course was composed of macadam limestone bonded with limestone screenings, and to measure 8 ins. in depth over the entire roadway between gutter flags after rolling. On top of this was placed a layer of medium limestone bonded with limestone screenings, to measure not less than 4 ins. in depth over the entire roadway after rolling.

On top of the 4-in. limestone course was placed a layer of medium crushed granite, upon which was placed sufficient bonding gravel to thoroughly fill all interstices, and as the rolling was in progress the roadway was thoroughly drenched with water and the rolling continued until all water placed upon the pavement would seek the gutter, indicating a thoroughly bonded pavement. The course of granite was required to measure not less than 3 ins. over the entire pavement after rolling. On top of the bonded granite course was placed a ½-in. layer of pea granite, and the whole roadway thoroughly rolled, compressing, so far as possible, the pea granite into the bonding gravel. The gutters were then thoroughly cleaned by brooms and the entire street barricaded for one week to allow it to thoroughly dry out and harden. The avenue was then thrown open to traffic, and for seven years has required no maintenance further than cleaning and sprinkling, and has always been perfectly satisfactory to the abutting property owners who paid for the improvement.

At the time the Euclid Ave. paving was completed, there were many residence streets in Oak Park ready for improvement. A large majority of the petitions received by the Board of Improvements for paving of streets in Oak Park since that time have been for granite-top macadam, with a request that the specifications be the same as for Euclid Ave. Many streets up to the present have been paved in this manner, approximating $250,000, including those constructed by special assessment and private contracts.

Experience has shown there are a number of points to be observed in constructing granite top macadam pavements in order to give the best results:

1. It is advisable, where it can be done, to make a system out of each special assessment and pave all streets both ways within the district comprising the system, and thus avoid so far as possible the mud from unimproved streets being deposited on the pavement. A single paved macadam street extending into a district where all the cross streets are unimproved will be injured more from the mud of the cross streets being deposited on the paved streets than from all the traffic on the street in ordinary dry weather. It will further

*Abstract of a paper read at the annual meeting of the Illinois Society of Engineers and Surveyors at Peoria, Ill., Jan. 23-25, 1907.

†Commissioner of Public Works, Oak Park, Ill.

be found that where a single street is paved in an unimproved district, traffic (both heavy and light) will in nearly all instances go considerably out of the way in order to take advantage of a paved street, which is unfair to the owners of abutting property who have paid for the improvement.

2. One of the very important questions in constructing granite-top macadam streets is to give plenty of crown: 12 ins. on a 30-ft. roadway is none too much; also be sure that the rolling is continued long enough on the granite course to insure the street being thoroughly bonded.

3. One of the mistakes that is often made in constructing streets of this character is in using too much bonding gravel. Care should be exercised in spreading the gravel (and especially so when the gravel is wet and chunky), otherwise patches will appear where the gravel is greatly in excess, and other places where there is an insufficient amount to receive a bond. Any overplus of gravel on a street when opened for traffic will cause the pavement to become muddy in wet weather, and dusty in dry weather. The least amount of gravel that can be used and still have all interstices filled will give the best results, and cause the least trouble on maintenance in the future.

The average estimated cost of granite-top pavements in Oak Park is $1.35 per sq. yd., and granite curb and gutter 70 cts. per lin. ft.

TESTS OF SHEAR AND OF THE BOND OF STEEL IN REINFORCED CONCRETE.

The investigations relating to reinforced concrete which have been in progress for some time at the Engineering Experiment Station of the University of Illinois include tests to determine the unit values of shear in concrete and the bond between steel and concrete. The results of these tests are given in Bulletin No. 8 of the Experiment Station, which has been prepared by Prof. A. N. Talbot.

SHEAR.

It is very hard to devise a method of testing concrete in shear so as to avoid the failure of the piece either by crushing or in tension. After a study of all previous investigations on the subject two methods of testing were used. In the first, a hole was punched in a concrete plate or block, and this method will be referred to as a punching test. The second method consisted in breaking a short concrete beam which was restrained at the ends. This method will be referred to as the restrained beam test.

Three forms of test pieces were used in the punching tests—1, plain concrete plate, 13 × 13 × 3 ins.; 2, recessed concrete plate 13 × 13 × 5 ins. with a circular space 7 ins. in diameter and 2 ins. deep hollowed from the bottom; 3, a plate of the same sort as No. 2, but reinforced, in a horizontal plane, immediately above the recess by rods bent near the perimeter of the piece. In making the tests, the specimens were placed on a bed plate 1 in. thick, having an opening 6 ins. in diameter in the center. The load was applied through a spherical bearing block and a die 5⅛ in. in diameter placed on the test specimen formed the punching tool.

The test piece for the restrained beam test was 4 × 4 in. in cross section and 13 in. long. It was bolted securely at both ends to bed plates above and below, with a 4½ in. opening between end reactions. The fracture was caused by the pressure in the middle of a 4 in. plate on the testing machine.

Table No. 1 gives a tabulation of the results of the tests with a comparison between the shear tests and tests of similar concrete in compression, both as a cube and as a cylinder. The bulletin gives the following summary of the tests.

1. It is difficult to devise a form of test specimen and a method of testing which will satisfactorily determine the resistance of concrete to shear. The difficulties lie in the inability to secure an even distribution of the shear over the shear section, in the high cutting and bearing stresses developed, and in the complications formed by the compressive, tensile, and bulging and bursting stresses developed. The forms of test specimen here used are not fully satisfactory, but information concerning the shearing resistance of concrete may be drawn from the tests as a whole, and tentative values selected. A test specimen in the form of a beam and in which the load is applied evenly over the depth of the beam instead of on the top is suggested.

2. The resistance of concrete to shear is dependent upon the strength of the stone as well as upon the strength of the mortar, and for the richer mixtures the strength of the stone probably exercises the greater influence. With hard limestone and 1:3:6 concrete 60 days old the shearing strength may be expected to reach 1,100 lbs. per sq. in., and with the 1:2:4 mixture 1,300 lbs. per sq. in. It seems very probable that the resistance to simple shear is considerably higher than this, and that tests made with the load applied evenly over the shearing section will verify this.

3. Since the compressive strength of concrete is influenced largely by the strength of the cement and the shearing strength is much more influenced by the strength of the aggregate, it does not seem proper to express the shearing strength in terms of the compressive strength. However, this is frequently done and is of advantage in gaining a conception of their relative action. It appears that the shearing strength is, in general, at least 50% of the compressive strength, and that is may exceed 75%. The apparent exception to this is explained by the high values obtained in the 1906 compression tests. These conclusions agree in a general way with the statement of other investigators that the shearing strength is as much as two-thirds of the compressive strength. Evidently the shearing strength of concrete is several times its tensile strength.

BOND OF STEEL IN REINFORCED CONCRETE.

In the earlier tests of the bond between steel bars and concrete, both plain and deformed bars were used, the latter being of the Johnson corrugated pattern, and affording a mechanical bond with the concrete. A summary of these tests is tabulated below, and it may be noted that in all the tests with the Johnson bars the concrete split, while in all the others the plain bars slipped.

TABLE I.—SUMMARY OF SHEAR TESTS.

Form of Specimen	Kind of Concrete	Number of tests	Strength lbs. per sq. in. Shear	Cube	Compression Cylinder	Ratio of shear to compression Cube	Cylinder
Plain plate	1:3:6	9	679	1,230	....	.55	....
	1:3:6	7	729	1,230	....	.59	....
	1:3:6	4	905	2,428	1,322	.37	.68
	1:3:6	1	968	1,721	1,160	.56	.83
	1:2:4	5	1,193	3,210	2,430	.37	.49
Recessed block	1:3:6	17	796	1,230	....	.65	....
	1:3:6	6	692*	1,230	....	.56	....
	1:3:6	5	879	1,230	....	.71	....
	1:3:6	4	1,141	2,428	1,322	.47	.86
	1:3:6	1	910	1,721	1,160	.53	.78
	1:2:4	5	1,257	3,210	2,430	.39	.52
Reinforced recessed block	1:3:6	4	1,051	1,230	....	.86	....
	1:3:6	4	1,821	2,428	1,322	.75	1.38
	1:3:6	1	1,555	1,721	1,160	.90	1.39
	1:2:4	5	2,145	3,210	2,430	.67	.88
Restrained beam	1:3:6	4	1,313	2,428	1,322	.54	1.00
	1:3:6	1	1,020	1,721	1,160	.59	.88
	1:2:4	6	1,418	3,210	2,430	.44	.58

*Specimens injured in removing the forms.

TABLE II.—TESTS OF BOND IN REINFORCED CONCRETE.

(Tests of 1904)

	Bars.	Max Load lbs.	Load per sq. in. of— Net section lbs.	Net surface lbs.	El. limit of steel lbs.
½-in	Johnson...	14,990	74,950	625	60,000
"	" ...	14,210	71,050	593	60,000
¾-in.	Johnson...	17,175	47,050	573	58,300
"	" ...	13,975	38,300	466	58,300
"	" ...	11,755	32,200	392	58,300
⅝-in.	square....	6,850	42,800	357	45,000
"	"	5,850	36,550	305	45,000
"	"	4,780	29,900	250	45,000
½-in.	square....	7,910	29,320	317	33,300
"	"	6,400	23,700	256	33,300
¾-in.	square....	11,850	21,100	329	35,000
"	"	11,600	20,620	322	35,000
⅝-in.	round	3,860	34,200	270	42,500
"	"	3,255	28,800	228	42,500
¾-in.	round	11,000	27,500	386	40,500
"	"	7,000	15,500	245	40,500

(Tests of 1905-06.*)

	Length encased ins.	Max. Load lbs.	Bond per sq. in. lbs	Running friction Max. lbs.	Running friction per sq. in. lbs.	Ratio of run. fric. to bond
½-in. round..	6	3,498	372	1,983	210	57.0
⅝-in. round..	6	4,170	355	2,700	227	64.0
½-in. round..	12	7,035	373	5,066	268	72.0
⅝-in. round..	12	9,458	402	5,366	228	56.8
1-in. shafting.	6	2,570	136	1,256	67	49.2
1½-in. shafting	6	1,476	157	466	50	31.8
Mild steel, 5/16 × 1½ ins..	6	2,536	125	1,713	84	67.1
¾-in. rd. tool steel	6	2,077	147	....	....	....

*Concrete, 1:3:5½.

The tests made during 1905 and 1906 included no deformed bars, but smooth finished bars or shafting were tested in addition to the ordinary rolled steel bars. A summary of these tests is also given in the accompanying table, and the bulletin reviews the results of the tests as follows:

1. Little difference is found in the bond resistance per sq. in. of surface of bar in contact with the concrete whether the bar is embedded 6 ins. or 12 ins. Evidently a length may be found beyond which the stre[ngth] of the steel would cause uneven distribution of the bo[nd] along the length of the bar and cause failure [to] gin at the point of greatest stress in the steel a[nd] give results not representative of the real [re]sistance. This limitation applies to length for [tests] in experimental tests of bond. In simple beams [the bond] stresses are applied along the length of the [bar] and stretch and bond exist together.

2. The richer mixture of concrete gives [somewhat] higher bond resistance than the leaner: the [values] for the 1:2:4 concrete averaging 10% to 15% [higher] than for the 1:3:5½ concrete. For plain round mild steel rods, the average for the bond resistance [ranges] from 350 to 450 lbs. per sq. in. of contact surface.

3. The flat bars gave much lower resistance than round bars, but only three tests were made with flat bars, and these may not be representative. It must be noted that the results with flat bars are much lower than tests made elsewhere. It should also be noted that for a bond stress of 125 lbs. per sq. in. the tensile stress developed in the bar was only 9,000 lbs. per sq. in.

4. The value of bond resistance will depend upon the smoothness of the surface of the bar, the uniformity of its diameter and section, the adhesive strength of the concrete, and the shrinkage grip developed in setting. The effect of smoothness of surface and uniformity of diameter and section is seen in the tests made with cold rolled shafting and tool steel. The average bond developed with these was 147 lbs. per sq. in. of contact surface, as compared with about 400 lbs. per sq. in. for ordinary plain, round, mild steel rods. Not only was there a very noticeable difference in the smoothness and finish of the surface of the rods, but the section of the cold rolled shafting and tool steel was very uniform, the diameter not varying more than 0.0001 or 0.0002-in. at ¼-in. intervals throughout the length, while mild steel rods will vary as much as 0.0015 in. It is to be expected that the smoothness and uniformity of section of drawn steel wire will operate to give low values of bond resistance, though, of course, as the section of wire is small compared with the circumference, the bond stresses developed when wire is used are relatively small. In reinforced concrete beams* the bond stresses developed in beams failing by tension of the steel, diagonal tension of the concrete or other similar methods, amounted to from 73 to 193 lbs. per sq. in. Even at the breaking load, then, the bond stress developed in the mild steel rods was far below the bond resistance found in these tests.

5. The bars began to slip when the maximum load was reached. After slipping began, the resistance to motion was still considerable. This running friction, taken when the bar had moved about ¼-in., amounted to 54% to 72% of the bond developed in the case of mild steel bars, and to 32% to 49% in the case of the cold rolled shafting.

In connection with the preceding tests of bond in reinforced concrete, we give below some description of tests conducted at Washington University, St. Louis, Mo., under the direction of Prof. J. L. Van Ornum, M. Am. Soc. C. E. These particulars are taken from a paper by Prof. Van Ornum on "The Fatigue of Concrete," which was published in the "Proceedings" of the American Society of Civil Engineers for December, 1906.

In the large majority of cases, those in which the development of diagonal cracks formed an essential factor in the fatigue of the beam, it appears that the gradual and progressive destruction of the adhesive bond of the concrete to the steel produced a vital influence upon the phenomena. Of course, usually, but not invariably, this destruction of the adhesion originated near the centre (of length) of the beam, and progressed toward, without reaching, the ends. This slipping of the bars in the concrete was shown to be closely related to the development of the diagonal cracks, by breaking open beams (previous to final failure) both before and after the appearance of these diagonal cracks, the evidences of slipping being present after diagonal cracks developed, but usually not evident before.

These evidences of slipping were various. On breaking apart the beams, there was found at the ends a noticeable and effective tendency of the concrete to adhere to the steel; while in the middle portion there was a space over which this adhesion was entirely lacking. The evidence alone is not convincing, but when considered in connection with the phenomena following, it would seem to be conclusive. Close examination disclosed the fact that, where the bond remained effective, the surface remained dull; but it had a polished, glossy appearance when the bond seemed broken. Often such surfaces revealed minute, but plainly discernible, horizontal striations. These must have been caused by a

*Bulletin No. 4, Engineering Experiment Station, University of Illinois, Urbana, Ill.

relative longitudinal movement taking place between the surfaces of the two materials, thus etching the smooth concrete surfaces by small projections from the steel. Such striations were rarely found when essentially no impressive failure occurred, but they were invariably present when diagonal cracks were prominently in evidence. Certainly, this relative longitudinal movement could not occur while the adhesive bond was effective.

Again occasional, very shallow, cavities (perhaps ¼-in. long, ⅛ in. wide and 1/100 in. deep) in the reinforcing bars were found, in one end of which there was a most finely pulverized cement dust, where the above-mentioned evidences of slipping were also present. This cement dust was invariably at the side of the depression toward the nearest place of unbroken adhesion, the remainder of the cavity being empty, as indicated in the accompanying normal section. Evidently, this phenomenon must indicate a relative longitudinal movement of

SECTION OF REINFORCING BAR.

the two materials, necessarily taking place only after the bond was destroyed, the sharp edge of the depression scraping off particles from the concrete and receiving them as repetitions continued.

Another phenomenon, which the writer can explain only by the same proposition, was the occurrence sometimes of a succession of distinct, metallic reports, plainly heard when the load was being applied, followed by a continuous low, rasping sound as the beam was relieved of its load. This certainly proceeded from the interior of the beam, as made evident by careful auditory scrutiny and by the fact that no external deterioration of the beam was discoverable at the same time. It is believed that it was caused by the sudden breaking in detail of the adhesive bond at points where its unusual strength brought a concentration of stresses upon them.

The adhesive strength of concrete to steel, low in value at best, is undoubtedly severely tried by repeated application and relief of load, and the consequent successive production and relief of the various internal stresses which tax so severely this essential and vital factor of reinforced concrete design and construction. Passing without comment the acknowledged fact that scale or thick rust will seriously impair the adhesion, it may be said that numerous critical examinations plainly indicated that any rust on the metal (while completely absorbed by the concrete and so effectively preventing further corrosion) did materially lessen the normal adhesive power of the concrete. The bond was often found lacking opposite the rust discolorations on the concrete, while remaining firm on each side where rust had been entirely absent; and, where the adhesive bond was destroyed in the middle portion of the beam, this destruction habitually terminated in a discolored section, apparently indicating the encountering of an increased adhesive resistance at the cleaner portions of the steel.

Another fact that has escaped deserved attention is the probability that a material excess of water used in mixing the concrete apparently lessens its adhesive power. It is realized that a moderately wet mixture is desirable, in order to prevent voids in the concrete as ordinarily placed, and especially to secure sufficient plasticity to insure a complete filling of the space round and below the network of reinforcing steel. But there seems to be a real danger that the reaction against dry concrete is being carried too far. An excessively wet concrete, not only contains numerous globules of water which, when absorbed, leave the concrete porous, but these, also, especially weaken the adhesion of the concrete to the steel, because there is a tendency for such water globules to seek the surface of the reinforcement, particularly on the under side. The weakening of the bond from this cause was evident in certain beams in which the adhesion was noticeably weak, the water cavities being apparent at the bottom and sides of the steel bars.

FATIGUE OF BOND OF CONCRETE TO STEEL.—For these tests, ⅝-in. square, plain steel bars were embedded in concrete, the bar being placed with its center 1 in. from the tension face of the embedding prism and midway between the sides. These imbedding prisms were 4 × 4 ins. in cross-section and 15 ins. long. The specimens were made with great care, and were very thoroughly tamped. They remained in the molds for two days, were then placed in water for seven days, and then stored in air for three weeks, thus being tested at an age of one month.

The machine devised to act upon the specimens consisted of two parallel steel struts, traveling in guides, to which a reciprocating movement was given. Beyond the guides, a metal cross-head was attached to these struts, faced with 1½ ins. of oak. In front of this oak face the specimen was clamped into a quite rigid frame, the attachment of the specimen to its independent frame being by heavy screw-clutches clamping the projecting ends of the reinforcing bar just beyond the ends of the concrete. The specimen was thus supported by the metal reinforcement, and a combined blow, pressure, and the accompanying vibration was imparted to it by the machine acting upon the surface of the embedding concrete. The number of blows delivered per minute was 150.

The specimens were set in their adjustable supports so as to encroach upon the extreme reach of the striking head 7/100 in. Measurement developed the fact that each blow imparted to the specimen about 740 in.-lbs. of work; of this amount, somewhat less than one-tenth was found to be expended in initial impact, an unknown amount was lost through the beam supports, and the remainder was imparted to the specimen in producing bending stresses, vibration, etc. The effect on the test specimens produced by this treatment, therefore, is seen to be very severe, especially producing those effects which are often thought to prove destructive to the bond between the concrete and the steel; no one watching and hearing the action of the machine upon the test piece could doubt this severity of treatment.

In 18 specimens the rods were pulled from the concrete without subjection to such preliminary fatigue treatment. For this case the average value of the strength of the bond was 150 lbs. per sq. in. of surface of contact, the extreme range from this mean value being about 35%. After the initial rupture of the bond, the weighing beam was again balanced as the bar continued to slip from the surrounding concrete, giving a frictional or sliding resistance averaging 100 lbs. per sq. in. of surface.

Of the 30 specimens subjected to the fatigue treatment of the machine, the number of blows given to each averaging 50,000, the average initial unit value of the bond was found to be 125 lbs. per sq. in. of surface, and the later frictional resistance, 90 lbs. per sq. in.; the range in values was about as before. The rigorous treatment described reduced, then, the value of the bond somewhat less than 20% in average value, and in no case as much as 50%. However, this reduction in value might easily be greater or less.

The total value of the bond consists of two parts; the adhesion proper, and the frictional resistance or "grip" of the concrete to the steel, independent of its adhesion. This frictional resistance is much the larger of the two, the value of the adhesion, proper, apparently being about 50 lbs. per sq. in. The "grip" of the concrete upon the steel is particularly dependent upon any effect of change of volume of the enveloping concrete, during both its setting and its hardening; and, consequently, its hygroscopic condition must constitute an important factor. The writer believes that very variable values would result from variations in the treatment of reinforced concrete, especially in connection with the presence or absence of water after it sets.

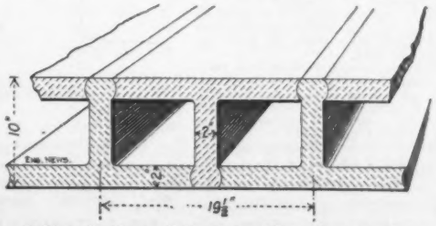
The same considerations may explain the low value found for the bond in the uninjured specimens, as compared with the greater strength reported by many experimenters, but agreeing more nearly with the lower values indicated by Considère, Hartmann and others. Variations due to proportions of ingredients, age, conditions of materials, and other considerations have received much attention; probably many discrepancies still remaining in values obtained by different experimenters would be explained if the moisture conditions of the specimens, from fabrication to test, were carefully scrutinized in their effect upon change of volume of the concrete as affecting the intensity of bond.

With reinforcing bars having no mechanical bond, the reduced value of the bond caused by great excess of water in mixing the concrete, by rust, scale, etc., is considerable, and, especially, the effect of moisture condition, in expanding or contracting the concrete and so affecting the strength of bond, seems to be a consideration worthy of attention and of more precise and extended investigation.

A NEW SYSTEM OF CONCRETE FLOOR CONSTRUCTION.

The novel system of concrete floor beam construction shown herewith has been devised and offered for use by Mr. M. Marti, 13 Yuen-Ming-Yuen Road, Shanghai, China. The system is of a similar type to the "Visintini System," described in this journal March 2, 1905, p. 218, viz.: consisting of beams made in a shop and brought to the work and set up as separate and distinct members of a floor construction.

These beams, however, in no way resemble in their design the beams invented by Mr. Visintini. The Marti System consists of juxtaposed single T-beams, with the flanges alternating at top and bottom, the side faces of both upper and lower flanges being cut into a concave-convex joint to permit of a closer union of the individual T's. It is advertised as reinforced concrete, though no steel is shown in any of the drawings or descriptions. The beams are made in Shanghai and sold in different sizes, as required.



A New System of Concrete Floor Construction.

In a recorded test of five beams, 3 ft. 3 ins. wide, 10 ins. deep and 16 ft. span, the floor deflected 5/16-in. under a total uniform live and dead load of 19,555 lbs., a load of 376 lbs. per sq. ft.

PROGRESS ON THE NEW YORK BARGE CANAL.

Col. Thos. W. Symons, of the Board of Advisory Engineers on the New York Barge Canal Work, has made a report to the Secretary of War summarizing the status of this work. Most of the report repeats the information given in the report of State Engineer Van Alstyne, in our issue of Jan. 3, p. 5, but the following extracts are deemed worthy of presentation here:

The depth of all the canals will be 12 ft., with a variable width depending on location, character of material, etc. In the larger lakes and canalized rivers the width will be 200 ft. on the bottom; in the smaller rivers and valleys the width on the bottom will vary from 100 to 150 ft. The canal sections proper in earth, with side slopes of 1 on 2, will have a minimum bottom width of 75 ft., and in rock cuts and vertical wall sections the minimum width will be 94 ft.

The locks will have this depth of 12 ft. and a width of 45 ft. and a usable, or net, length of 310 ft.

It will be observed that the locks and the canal prism away from rivers and lakes are not properly proportioned to each other. This arises from the fact that the canal prism was designed to fit locks 28 ft. wide, and that the locks were afterward ordered by the Canal Board of the State to be widened to 45 ft. And as it is deemed possible that the canal prism may in the future be widened to correspond with the widened locks, the precaution is being taken to procure now a right-of-way wide enough for the purpose, and in depositing spoil and embankments to place them far enough away from the canal so that they will not have to be rehandled in the future should the prism be widened.

An interesting episode connected with the locks occurred in the early stages of the work. When the stonecutters of the State learned that it was proposed to build the locks and other masonry structures of concrete, they inaugurated a campaign to compel the use of stone. The advisory board made a report that the additional cost to the State from using stone over using concrete would be about $16,000,000, and that no benefit therefrom would accrue to the State. This ended the campaign. This is believed to be a good indication of the value of concrete.

To determine the nature of the material through which the canal passes, and particularly at lock and dam locations, a vast amount of boring has been done. The linear feet of boring for which reports have been received to Jan. 1 is 216,125 ft., or about 41 miles.

PREVENTION OF UNBALANCED BIDS.

There is one feature of the work of preparing estimates and letting contracts on this work which is worthy of special attention because of its effect in preventing unbalanced bids, collusion, etc. The Engineer Department makes a careful estimate of the amounts of each particular item of work embraced in the contract, a proper unit price for each of these items and the total cost of all the work, based on these estimates of quantities and adopted unit prices. No bid is accepted for any work when the bid on any item exceeds the item price of the engineer's estimate by more than 20% or when the total bid exceeds the engineer's total estimate by more than 10%.

EXCAVATION UNCLASSIFIED.

Another important feature of the work is that in any section all excavation is paid for at one unit price, no matter what the material may be. This removes a fruitful source of trouble and possible collusion and corruption. Through borings, as careful a determination as practicable is made of the different kinds of material met with. All this information is studied by the engineers in making their unit prices, and is available to the bidders and contractors, and the final composite or unclassified price for the excavation is based thereon.

ELECTRIC TOWAGE.

Two years ago the State constituted an Electrical Towage Commission to inquire into the subject of electric towing on the canals. As a member of the advisory board I was a member of this commission. From its investigations this commission became convinced that no system of electric towage yet devised was adapted to propelling boats on the improved barge canals of the State.

and bounded by east-west lines parallel to the street, would accommodate a straight 60-ft. structure connecting the east and west bank centrally on the respective streets, but for the fact that it was desired to reserve the southerly 30-ft. width of this right-of-way from the east end to the river for a road leading down into the valley. The program required competitors to give particular attention to the matter of location, but did not clearly state what points and requirements were to be taken as fixed data in planning out the location.

The solutions of this difficulty in the competitive designs showed considerable variation. The first prize design adhered rigidly to the implied requirement of keeping entirely outside the southerly 30-ft. strip on the eastern part of the site, by laying down a reverse curve or S-shaped line as the center line of the viaduct; the end tangents of this curve were parallel to the street center-line and were located in the northerly half of the right-of-way, and the curve was such that the southern edge of the structure would just pass the northwest corner of the reserved strip. The other solutions employed as a center line either a single straight line or a broken line consisting of a prolongation of the street line at either end with a straight connecting portion at an angle to the street line.

The commission of award, recognizing the great limitations put upon the designer by the requirements as to location, recommended that the contract designs should provide for central approach to the street at either end, and a straight instead of a curved or broken center line; additional land to be purchased for a 30-ft. road into the valley alongside the viaduct so located.

FIRST-PRIZE DESIGN: MELAN ARCH.

The design "M. V. M.," which received first place, consists of ten arch-spans flanked by solid-fill approach sections walled in reinforced concrete. The arches are full barrel arches, circular segments in outline, carrying transverse spandrel walls supporting a reinforced roadway plate. Eight of the arches are 143 ft. in clear span, one is 100 ft. (over 38th St.), the last 60 ft. in span. The 143-ft. and 100-ft. spans have a rise of 28 ft., the 60-ft. span a rise of 15 ft. The structure is 2,084 ft. long end to end. The roadway surface is about 68 ft. at the west end and 78 ft. at the east end above water-level in the river, having a grade of 0.48% rising to the east. The plane of the springing lines is parallel to this grade. These figures, together with the general view, Fig. 1, herewith, represent the main outlines and dimensions of the design.

Details of the structural features, on the one hand, and of the architectural development, on the other, are given in Figs. 3 and 4, which sufficiently explain themselves. To this we may add that the piers, 14 ft. thick, are not designed strong enough to take a one-sided thrust, but require both adjoining arches to be in position. This means that concreting must progress simultaneously in all spans.

The proportioning of rise and span, which results in placing the springing lines high up on the piers, makes the variations of ground level insignificant and thus permits of using the same length of span for all the main arches. As already noted, the grade of the roadway is followed by the plane of the springing lines, each arch having its eastern skewback higher than the western. The arches, whether on straight or on curved location, are all of them square, and their side faces are chords of the curved location. The angle between adjacent spans is taken up in the pier between, which is made trapezoidal in plan.

The architectural treatment is simple. A molded band around each pier, just below the skewbacks of the arches, carries an escutcheon on the side face of the pier to mark more prominently the base of the arches springing from the pier. Similarly a molded panel above the crown of the arch, just below the cornice, emphasizes the key. Above the arch skewbacks, the pier is hollow; its side walls are formed by simple ornamental panels, while the wall toward either arch is the first spandrel support of that arch. Below the arch skewbacks each pier is separated into three parts by two arched openings cored through it, parallel to the axis of the viaduct.

The roadway is designed as a plate spanning between the transverse spandrel-walls, but each of these spans is shaped like a flat arch. The outer end of this false-arch barrel is coned out in concave form, for the purpose of emphasizing the line of these arches.

A heavy plain projecting cornice and a perforate concrete balustrade molded in place finish the top of the bridge. Both cornice and railing are offset outward over the piers, corresponding to the projecting panel on the face of the pier.

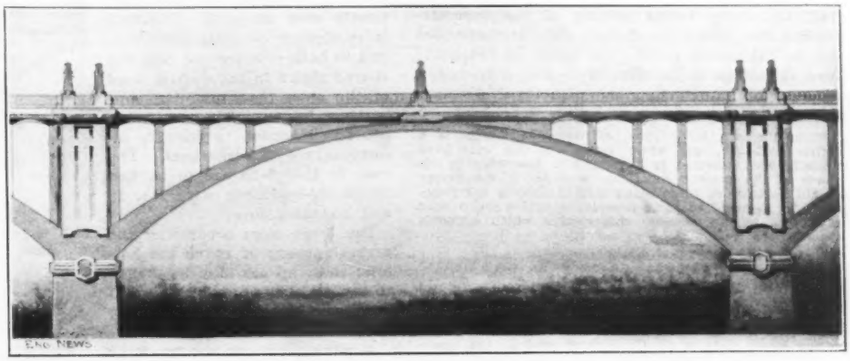
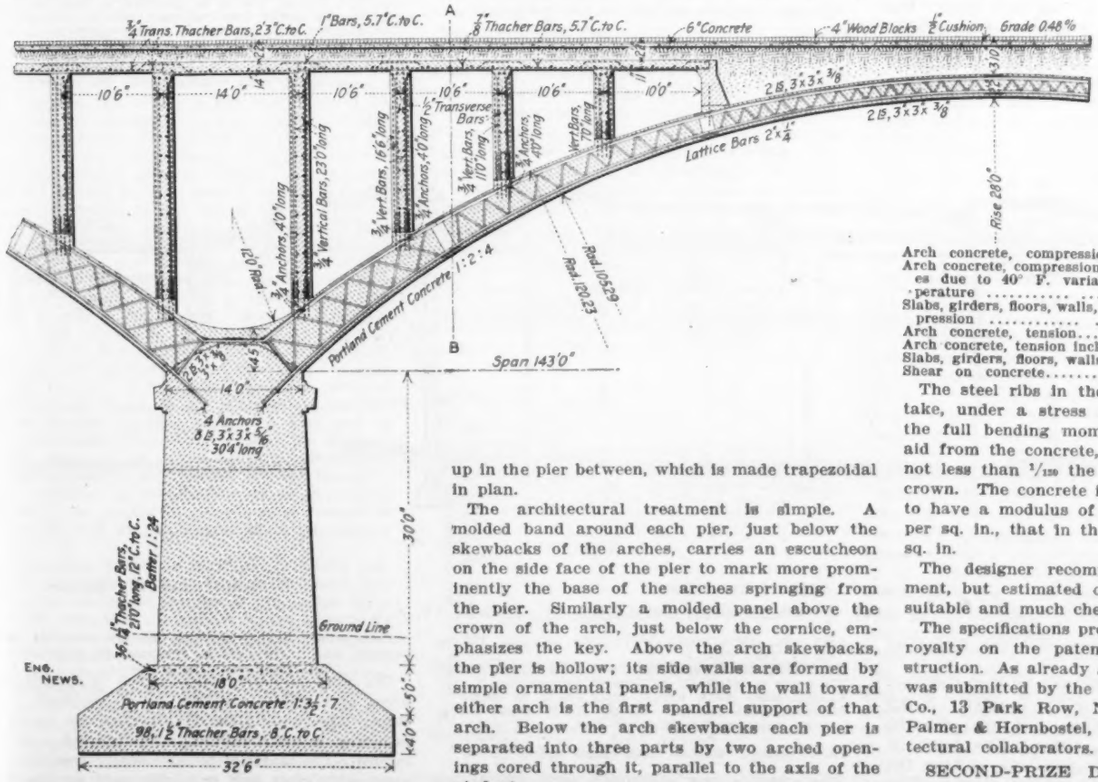


FIG. 4. SIDE ELEVATION OF ONE OF THE 143-FT. SPANS; DESIGN "M. V. M."

Two lamp-posts are set in the railing in this offset, and another at the center of the span. These are of concrete, and carry a bronze lamp-holder.

The specifications for the design "M. V. M." provide the following mixtures of concrete: For arches, slabs, girders, beams, floors, walls subject to transverse stress, 1:2:4 (1½-in. stone); for spandrel walls and retaining walls, 1:2½:6 (2-in. stone); for piers, abutments and foundations, 1:3:7 (3-in. stone); for all ornamental work, 1:2:4 (fine broken stone), faced with a liquid 1:2 mortar placed in the mold before the backing. The forms for faces of piers, abutments, spandrel walls, etc., are to be plastered with a mixture of plaster-of-paris and lime, so as to have a perfectly smooth face.

The design was based on the maximum stresses given below.



LONGITUDINAL SECTION OF 143-FT. MELAN ARCH; DESIGN "M. V. M."

Arch concrete, compression	500 lbs. per sq. in.
Arch concrete, compression, incl. stresses due to 40° F. variation in temperature	600 lbs. per sq. in.
Slabs, girders, floors, walls, etc., compression	Factor of safety of 5 in six months
Arch concrete, tension	50 lbs. per sq. in.
Arch concrete, tension incl. temp. stress.	75 lbs. per sq. in.
Slabs, girders, floors, walls, etc., tension	0
Shear on concrete	75 lbs. per sq. in.

The steel ribs in the arches were designed to take, under a stress of 18,000 lbs. per sq. in., the full bending moment on the arch without aid from the concrete, and to have flange areas not less than $1/_{120}$ the total area of the arch at crown. The concrete in the beams was assumed to have a modulus of elasticity of 2,580,000 lbs. per sq. in., that in the arches 1,500,000 lbs. per sq. in.

The designer recommended wood-block pavement, but estimated on vitrified brick as being suitable and much cheaper.

The specifications provide for the payment of a royalty on the patented system of arch construction. As already said, the design "M. V. M." was submitted by the Concrete-Steel Engineering Co., 13 Park Row, New York City, who had Palmer & Hornbostel, of the same city, as architectural collaborators.

SECOND-PRIZE DESIGN: HOOPED-RIB ARCH.

While the first-prize design is of a type which has been executed in many cases, and might

COMPETITIVE DESIGNS FOR A REINFORCED-CONCRETE VIADUCT IN MILWAUKEE, WIS.

A competition for designs for a long viaduct over the Menomonee Valley at Grand Ave., Milwaukee, Wis., has resulted in the award of prizes to two notable designs which we illustrate herewith. The structure was specified to be built of concrete or reinforced concrete, and to cost not over $400,000. Prizes of $1,500, $1,000 and $1,000 were offered. The commission of award consisted of Prof. F. E. Turneaure (Madison, Wis.), Mr. Ralph Modjeski (Chicago, Ill.) and Mr. Gustav Steinhagen (Milwaukee, Wis.). About a dozen competitors entered designs. The awards were as follows: First prize to the Concrete Steel Engineering Co., of New York, N. Y., for a Melan arch design, submitted under the nom de plume "M. V. M."; second prize to Mr. C. A. P. Turner in conjunction with Kees & Colburn, architects, of Minneapolis, Minn., for a hooped-rib arch design, submitted under the nom de plume "T. K. C."; honorable mention (no third prize awarded) to Mr. Charles F. Class, of Camden, N. J., for a design submitted under the nom de plume "A. N. Ingenieur." The names of the other competitors were not announced.

Grand Ave., running through the city of Milwaukee from east to west, is the main street of a high-class residential district, which has steadily developed and expanded. At 37th St., about four miles west of the shore of Lake Michigan, the broad, flat valley of the Menomonee River cuts across this street at right angles. Grand Ave. continues down into the valley, crosses the river on a low-level truss bridge, and ascends to the high ground beyond. The residential district, however, is effectively terminated at the edge of the depression, although an open region of high residential possibilities lies on the bluff to the west. Two or three hundred feet north, a steel viaduct, originally built for a steam dummy line, carries across the valley a line of electric surface cars, which run several miles westward to the suburban village of Wauwatosa, but this viaduct is not available for highway traffic. It may be seen that a high-level viaduct across the valley at Grand Ave. could not fail to have a very favorable influence on the westward development of the city.

In fact, local agitation for the construction of such a viaduct has been going on for more than a decade. Various causes, among them a dispute over the question high-level vs. low-level viaduct, prevented the realization of any definite action until about a year ago, when the general sentiment for a viaduct could no longer be gainsaid. Then there followed a long discussion as to the method to be followed in securing a design, which discussion was finally ended last summer by the appointment of a commission to institute and pass upon a competition for plans and specifications. This commission, composed as above noted, reported on Dec. 31, 1906. The Board of Supervisors of Milwaukee County, which has the building of the viaduct in charge, subsequently ordered that bids be requested on the two designs to which prizes were awarded.

Before describing the two prize designs we may refer to the program of competition, drawn up by Prof. F. E. Turneaure and Mr. Gustav Steinhagen of the commission of award.

The program contained a ground plan of the site, three profiles along the proposed location, cross-sections 50 ft. apart, and several photographs of the crossing. The profile also defined the length of the viaduct and the elevation of the two ends, the latter being such as to call for a mean grade of about ½% down to the west. Technical requirements were specified in substance as follows:

A structure of concrete or of reinforced concrete, the cost not to exceed $400,000.

A deck structure, with 40-ft. roadway, a 10-ft. sidewalk on each side, giving a clear width of 60 ft. between railings.

A span of 12-ft. clear headroom over 38th St., a clear span over a cross-road in the valley, a span over the full width of the C., M. & St. P. Ry. right-of-way in the valley, 24 ft. in clear height, and a span across the Menomonee River without a pier in the river.

A pavement suitable for heavy traffic, but not asphalt. Sidewalks of granolithic finish with concrete curb and gutter.

LOADING: Besides weight of structure, a load of 1,000 lbs. per lin. ft. for future street-car tracks, pipes and wires. A uniformly distributed live load of 100 lbs. per sq. ft. on roadway and sidewalks. A concentrated live load of 24 tons on two axles 10-ft. centers on the roadway. On each of two future street-car tracks 11-ft. centers, a 50-ton two-truck car, 22 ft. between truck centers and 6 ft. truck wheel-base. Temperature variations to be considered.

A sufficient number of ornamental lamp posts to illuminate the viaduct at night.

A substantial but ornamental railing, preferably of material not requiring special protection against rust or deterioration by the elements.

Competitors were required to furnish a complete description in addition to the plans and specifications, and also stress sheets with a full statement of the method of calculating stresses and cross-sections. The drawings required were:

A general plan and side elevation, to a scale of 20 ft. to the inch. This drawing shall preferably be on white paper, and may be shaded by a single tint.

Cross-sections to a scale of ¼-in. to the foot, and details to a scale of ¾-in. to the foot.

Important details, as railings, cornice and lamp posts, in one-half natural size.

Strain sheets and diagrams to a scale of forces not less than 1-in. to 100 cu. ft., and to a scale of lengths not less than 1 in. to 60 ft.

No isometric, perspective or water-color drawings were admitted.

Among the general conditions imposed [illegible] competitors were these:

Plans and specifications awarded prizes become the property of Milwaukee County, and the county reserves the right to advertise for bids on any one of those plans and specifications or on a combination [illegible].

Plans and specifications of unsuccessful designs will be returned to the persons submitting them and no compensation allowed therefor.

The county reserves the right to withhold the award of prizes, should none of the designs and specifications submitted come up to the standard of excellence called for in the program.

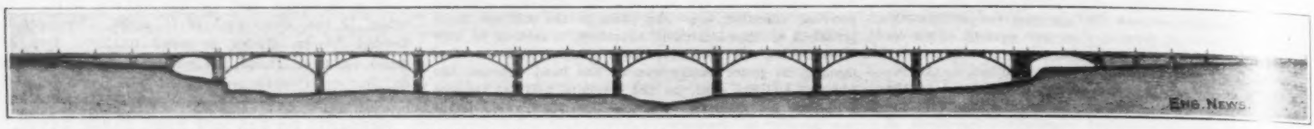


FIG. 1. "M. V. M.;" CONCRETE STEEL ENGINEERING CO., NEW YORK, N. Y., WITH THE COLLABORATION OF PALMER & HORNBOSTEL, ARCHITECTS.

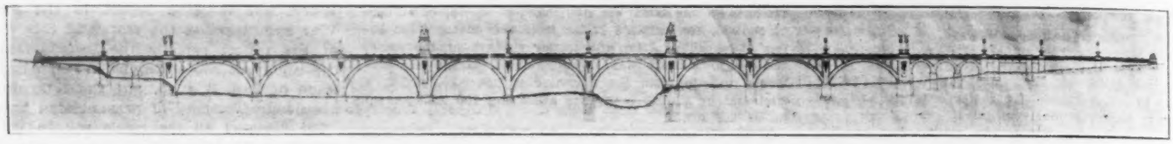


FIG. 2. "T. K. C.;" C. A. P. TURNER, MINNEAPOLIS, MINN., WITH THE COLLABORATION OF KEES & COLBURN, ARCHITECTS.

FIGS. 1 AND 2. COMPETITIVE DESIGNS FOR A CONCRETE VIADUCT OVER THE MENOMONEE VALLEY AT GRAND AVENUE, MILWAUKEE, WIS.

An important feature of the local conditions, though of no interest to the purpose of description, were the circumstances affecting the exact location of the structure. The street west of the valley is not in line with the eastern part of Grand Ave., but lies 17 ft. to the south. The right-of-way owned by the county, 100 ft. wide

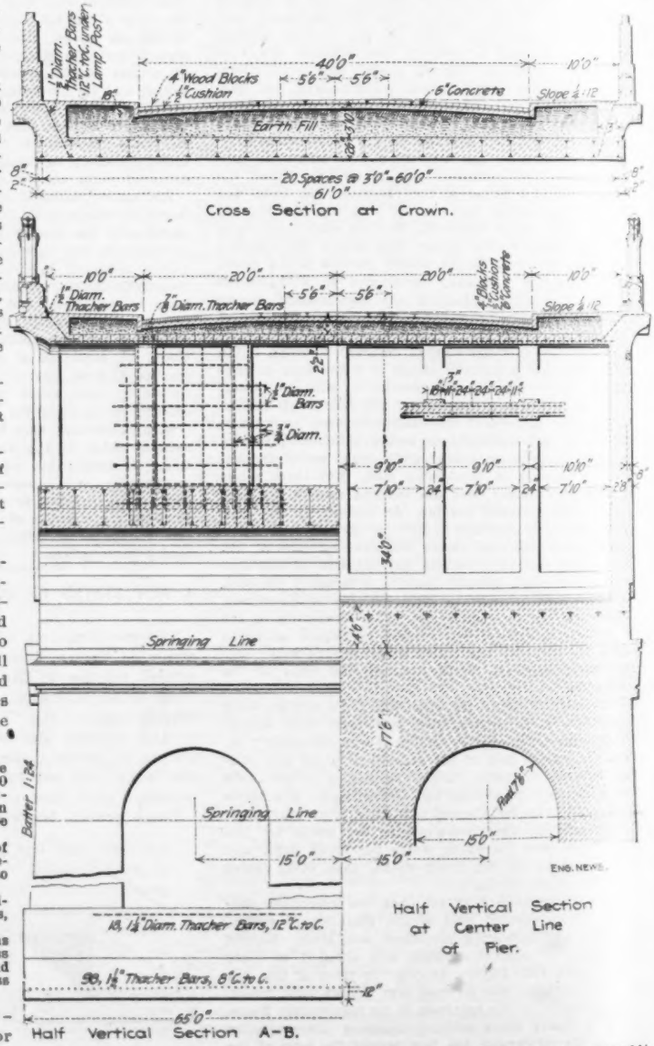
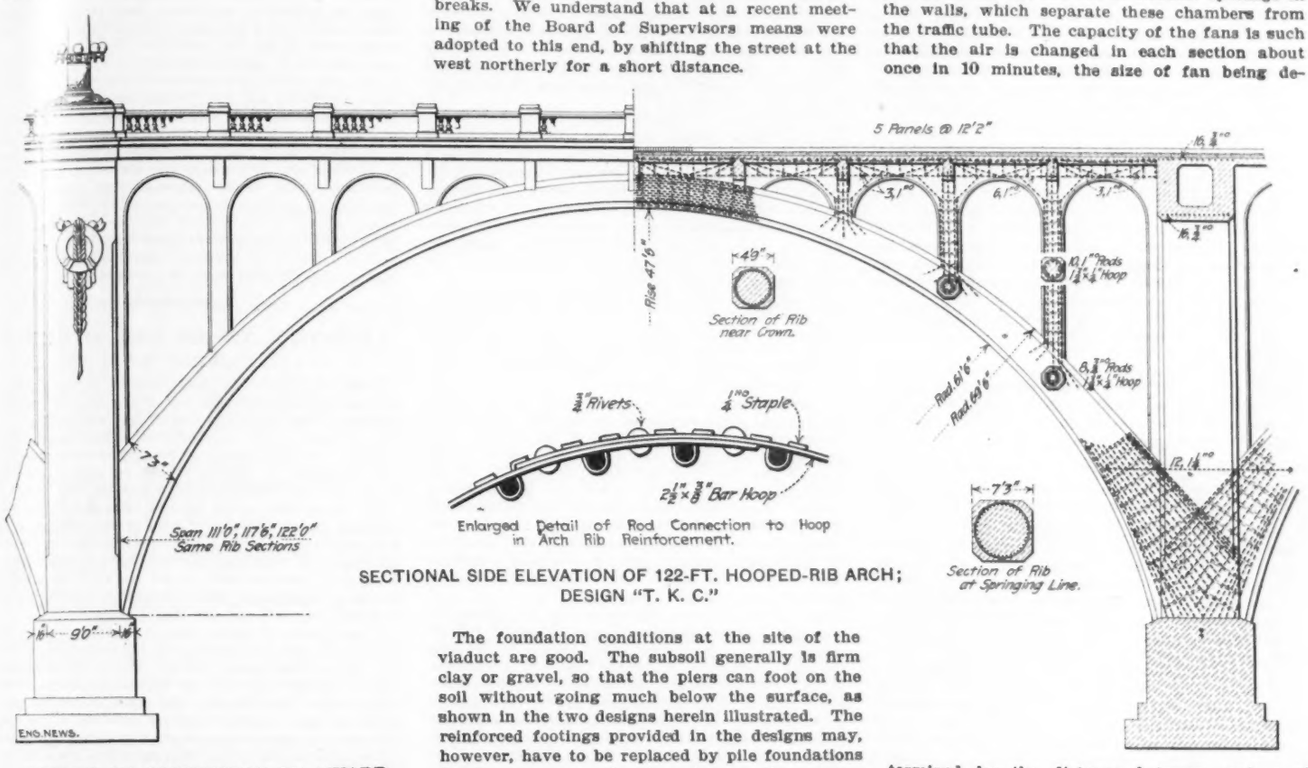


FIG. 3. TRANSVERSE SECTIONS OF 143-FT. MELAN ARCH; DESIGN "M. V. M."

and will not discolor or effloresce when exposed to the action of the elements. Bronze is to be used for all exposed metal parts, such as lamp fittings.

The commission further recommends that steps be taken to secure central approach to the street at either end, and to lay out the viaduct in a straight line between ends, without angles or breaks. We understand that at a recent meeting of the Board of Supervisors means were adopted to this end, by shifting the street at the west northerly for a short distance.

In the original subway, the ventilating chambers are placed at the side of the tunnel, midway between each two stations. Exhaust fans, two per chamber, are set in circular openings in the walls, which separate these chambers from the traffic tube. The capacity of the fans is such that the air is changed in each section about once in 10 minutes, the size of fan being determined by the distance between centers of stations and the area of cross-section of the subway, part of the subway being two and part four-tracked.



SECTIONAL SIDE ELEVATION OF 122-FT. HOOPED-RIB ARCH; DESIGN "T. K. C."

REPORT OF COMMISSION OF AWARD.

The commission reports on the competitive designs in substance as follows:

In the judgment of the board the best three plans submitted are, in the order of merit, the designs marked respectively, "M. V. M.," "T. K. C.," and "A. N. Ingenieur."

The analyses of the stresses submitted by the designers have been checked in all these plans and found to be substantially correct. All important structural features have also been examined and, excepting as hereinafter mentioned, are believed to be safe and adequate.

The design of "M. V. M." is well worked out in all respects and the proportions are good. In the estimate of the cost, however, no provision has been made for engineering or for electric wiring. The total estimate is $396,700, including profit and royalty. An examination of the detailed estimate leads us to believe that a considerable reduction in cost may be effected by using a somewhat less rich concrete in certain parts so that the total can be reduced to the limit of $400,000.

The second plan, that submitted by "T. K. C.," is a handsome structure, but considering the locality, we believe that it would not suffer in appearance by the omission of most of the statuary. From the structural point of view, the design is a rather bold one, and while designs of this sort have recently been executed in Europe, it is somewhat in advance of the present American practice. If the bridge should be built on these plans they should, in our judgment, be modified so as to provide expansion joints near each pier in the concrete construction which supports the roadway. The total estimated cost of this design is $395,000, not including engineering and electric wiring. There is, however, included an item of $34,000 for ornamental work, which can readily be reduced to an amount so that the total cost will be brought within the specified sum.

The third plan mentioned is, in our judgment, considerably inferior in design to either of the other two. If used, the location of the axis of the bridge would have to be changed, for as proposed by the designer its location now requires the purchase of additional land in order to provide the 30-ft. roadway along the south side of the viaduct. The cost of this structure, we believe, could readily be kept within the specified sum.

We would therefore recommend that the first and second prizes be awarded, respectively, to the first and second designs herein mentioned. We recommend, furthermore, that design No. 3 be given honorable mention, as it does not, in our judgment, have sufficient merit to warrant its receiving a prize.

The foundation conditions at the site of the viaduct are good. The subsoil generally is firm clay or gravel, so that the piers can foot on the soil without going much below the surface, as shown in the two designs herein illustrated. The reinforced footings provided in the designs may, however, have to be replaced by pile foundations for the piers near the river, in case the excavation does not disclose good material at moderate depth. Concrete piles will probably be considered in that case.

VENTILATION OF THE BOSTON SUBWAY.

In a paper presented at the annual meeting of the American Society of Mechanical Engineers, at New York City, Dec. 4-7, Mr. Howard A. Carson, M. Am. Soc. C. E., Chief Engineer of the Boston Rapid Transit Commission, described the ventilating system of the Boston subway, and we have taken therefrom the following facts:

The aggregate length of the subway is 4½ miles, composed of the original subway, the East Boston tunnel and the Washington St. tunnel. The general scheme of ventilation is that fresh air shall enter at the stations and portals and be drawn out by fans, placed midway between stations. The vitiated air is discharged by the fans, either through gratings in the sidewalks, through ornamental shafts, protected by low buildings, or through shafts carried above the surrounding buildings, the style of outlet depending on the location of the ventilating chamber.

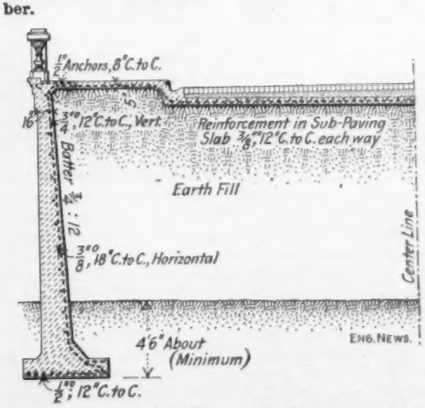

1" Anchors, 8' C. to C.
16"
3"/4", 12" C. to C., Vert.
Reinforcement in Sub-Paving Slab ⅜", 12" C. to C. each way
Batter ¾ : 12
Earth Fill
3"/8", 18" C. to C., Horizontal
Center Line
4'6" About (Minimum)
ENG. NEWS.
½", 12" C. to C.

Fig. 6. Cross-Section Through Solid Fill Approach; Design "T. K. C."

In the original subway, the ventilating chambers are placed at the side of the tunnel, midway between each two stations. Exhaust fans, two per chamber, are set in circular openings in the walls, which separate these chambers from the traffic tube. The capacity of the fans is such that the air is changed in each section about once in 10 minutes, the size of fan being determined by the distance between centers of stations and the area of cross-section of the subway, part of the subway being two and part four-tracked.

The same general arrangement of ventilation was provided for the East Boston tunnel as for the original subway, but to ventilate the portion under the harbor, where it is impossible to discharge directly to the outer air, ducts are placed in the top of the tunnel to carry the vitiated air to the shore, where it is exhausted (Eng. News, Dec. 29, 1904, p. 598). The fans used in this tunnel are of such a size as to change the air in each section about once every 15 minutes, the velocity of air varying from 1 ft. to 2½ ft. per second.

Fresh air will be admitted at the stations and portals of the Washington St. tunnel and withdrawn from the traffic tube at about midway points, the same as in the two tunnels mentioned above. However, as it is not practicable to discharge the vitiated air directly into the outer air at the points where it is taken from the traffic tubes, the vitiated air will be passed through specially constructed ducts, in some cases located underneath and in others above the tunnel, having a minimum cross-section of 40 sq. ft., to convenient places of discharge. Each section will be provided with two fans of sufficient capacity to change the air about three times per hour, the velocity of air in the tunnels being upward of 1 ft. per second.

Commenting upon the ventilation of electric subways in general and the absence of positive mechanical ventilation, Mr. Carson gives the accompanying table, showing the vitiation of the air in the Boston subway at a time when traffic was large and no fans running, and that in various halls, theaters, churches, schools, etc., of Boston, as appearing to justify the omission of positive ventilation in electric subways, but says:

The fitness of air in the subway for breathing, however, can probably be better ascertained by means of sensitive noses of persons used to fresh air than by the ordinary methods of chemists. Crowded unventilated subways contain not only carbonic acid and other matters thrown off from human lungs but have also, widely diffused through the air, fine dust from the ballast, fine particles of oil from the machinery, and finely ground

therefore be called a conventional design, the design "T. K. C." involves some distinctly novel features. It employs in its arch spans isolated ribs, in place of an arch barrel, carrying columns on which the roadway girders rest; the arch ribs as well as the columns are reinforced with hooping, as originally recommended by A. Considère. Sand-cast artificial stone is employed for the railing and ornamental work. Moisture-pockets in the arch-centering are specified, to ensure better setting of the concrete. Unlike the first-prize design, this one provides for no expansion joints, but takes up temperature variations in its elasticity. The commission of award characterizes the structural features thus:

From the structural point of view the design is a rather bold one, and while designs of this sort have recently been executed in Europe, it is somewhat in advance of the present American practice. If the bridge should be built on these plans they should, in our judgment, be modified so as to provide expansion joints near each pier in the concrete construction which supports the roadway.

The design employs statuary as ornamentation of the deck, but the commission recommends that most of this be omitted.

The design as a whole is shown in Fig. 2, and in its main details in Figs. 5, 6 and 7. It comprises a series of nine circular arches, three of span 111 ft. 0 ins., four of span 117 ft. 6 ins., and two of span 122 ft. 0 ins. Several minor spans and long solid fill approaches carry the structure to a total length of 1,767 ft. The crossing over 38th St. is a girder-span of 42 ft. clear (Fig. 7). The arches are of much greater rise than those of the first design, and therefore, to maintain similar form of arch as the ground level varies, are made of different lengths of span. This is kept from breaking up the unity of the structure by arranging three groups of three spans, having piers, and ornamental pylons crowned with statuary, mark the divisions between the groups.

Structurally, each arch span is carried by three parallel ribs of octagonal section, braced together by struts at the haunches and directly by the floor beams in the crown section. The outer arch ribs are 43 ft. 6 ins. apart c. to c., the sidewalk cantilevering over. A reinforced slab-and-girder roadway floor is supported by hooped columns footing on the arch rings. The arch ribs foot on the piers near the ground level. Above this point each pier divides into three pilasters, joining below the roadway floor by arches. Thus the piers aim at the same degree of lightness which characterizes the design of the arches themselves.

The arch ribs were designed of sufficient section and reinforcement for the longest (122-ft.) span; the same sizes were then used for the 117½-ft. and the 111-ft. spans. The depth of rib chosen is "practically sufficient to keep the line of thrust within the middle third." The reinforcement consists of round rods arranged in circular spacing near the outside of the cross-section, together with riveted hoops of flat steel; the hoops are tied to the main rods by ¼-in. staples driven through holes punched in the hoops and clinched. The main rods are spliced by threaded ends fitted with pipe turn-buckles.

The girders and slab of the roadway floor are reinforced with round rods; the reinforcement is designed to give continuity over supports. The slab is reinforced in both directions, and in both systems the rods are spaced closer in the middle third of the span than near the supporting beams. The reinforcement is intended to take up all temperature deformations. The rods in the slabs are to be tied at all intersections with No. 18 soft annealed wire.

The large piers separating the several groups of spans are hollow; these spaces may be turned to use as storage chambers or to accommodate stairways leading to the valley below.

A paving of vitrified brick or creosoted wood blocks is intended. To minimize the impact effect of wheel loads on the roadway there is a filling of tar macadam between paving and floor-slab.

The architectural treatment, excepting the symbolic groups of statuary flanking the roadway, is very simple. A plain cornice effect is produced by the edge of the sidewalk slab, and is set off by the sidewalk brackets below. The balustrade is built up of special concrete sections cast in sand. These features, with lamp-posts formed as ornamental columns, and a decorative panel on the face of each pier, are the only esthetic elements other than that contained in the general design and arrangement of parts.

The materials to be used in the work are:

Concrete:
Foundations, below water-table, 1:3:8 (5 parts 2-in. to 3-in. stone, 3 parts 1-in. to ⅝-in. stone.)
Facing of piers above ground level, 3 ins. thick, 1:2:3 (stone ⅝-in. down.)
Arch ribs, piers above water-table columns, 1:2:3½ (⅝ to ¼-in. stone.)
Floor slab, beams, spandrels, etc, 1:2:4 (⅝-in. down.)
Top finish of sidewalk, 1:2 (coarse torpedo sand.)
Railing, lamp posts, pylons, 1:1:2 (½-in. to dust.)
Statuary, shell sections, 1:1:1½ (sand, white silica; stone, white marble, ½-in. to dust.)
Interior, 1:3:5.
Reinforcement: medium open-hearth steel.

The specifications submitted with the design do not give unit-stresses or other design data, but are very full in defining execution and workmanship. The arch centers are to incl[ude] a special detail:

The bottom of the boxes [rib forms.—Ed.] to be arranged with suitable sand pockets to enable the use of a more liquid concrete and to improve crystallizat[ion].

Elsewhere the specifications state that

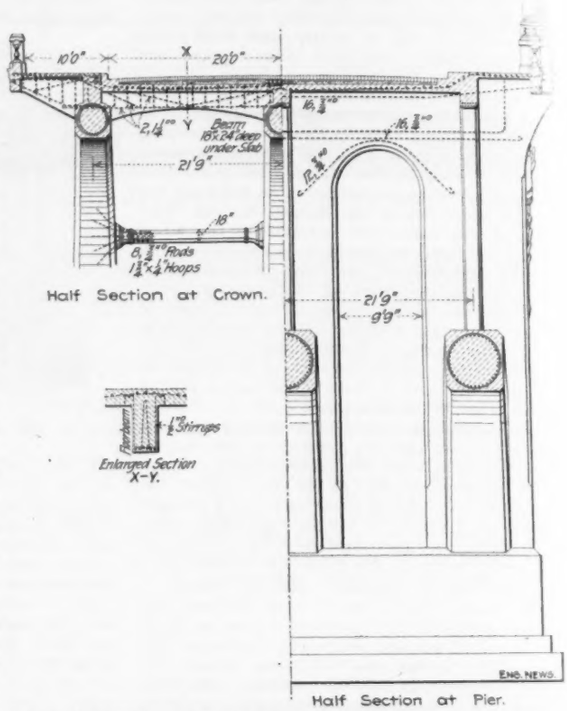


FIG. 5. SECTIONS OF 122-FT. HOOPED-RIB ARCH; DESIGN "T. K. C."

arch-rib concrete is to be mixed semi-fluid. A fuller statement concerning the sand-pockets is given in the description accompanying the plans:

Boxes for sand pockets, at suitable intervals on the sides and bottom, are to be provided so that the concrete can be flowed into the main ribs in a semi-fluid condition, and that the sand in these pockets will absorb the excess water, causing the semi-fluid concrete to be settled or consolidated in the most perfect manner possible, with the resulting improved crystallization due to this consolidating effect combined with the induration of the concrete by giving back the moisture from the sand pockets, as it is required by the concrete in setting up.

The sand-cast ornamental work is specified to have only 6% absorption in a seasoned 2-in. cube. The description states that the designer proposes, in casting the parts in a sand mold, to indurate the material by chemically treating the sand with alum and sulphuric acid so that the concrete will be practically impervious to water

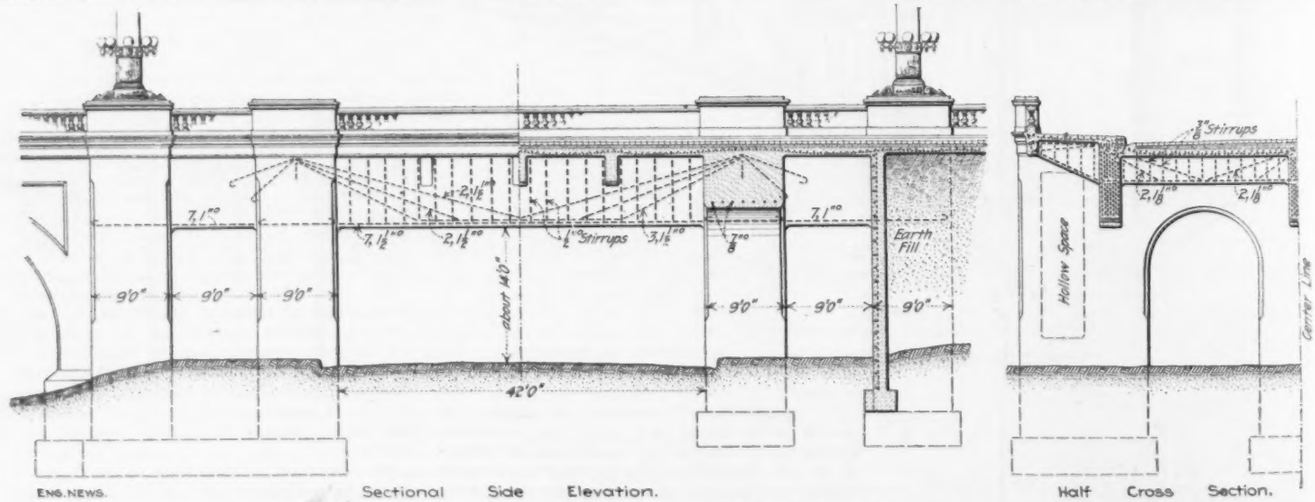


FIG. 7. GIRDER SPAN OVER 38TH ST.; DESIGN "T. K. C."

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The bid of the Oliver-McDonald combination for completing the Panama Canal was filed with the Canal Commission on Feb. 7, and the following official statement concerning it was given out:

> The bid of the Oliver-McDonald combination has been received and examined and meets the formal requirements. Mr. Paul D. Cravath on behalf of his clients, the MacArthur-Gillespie combination, has requested a hearing before final action is taken. In addition to granting this hearing the Secretary of War and the Isthmian Canal Commission will make as thorough an examination as possible into the qualifications, experience and business standing and achievements of Mr. Oliver and associates, and into the responsibility of the sureties. Secretary Taft and the Commission will probably need a fortnight to complete full examination of the bid and report to the President.

Newspaper dispatches from Washington on the same date told with great show of particularity that the Administration was hesitating whether to let contracts at all because, forsooth, Chief Engineer John F. Stevens had cabled that if contracts were now let he should at once resign for fear the contractor and not he would get the credit for building the canal!

It is entirely safe to set this story down to the credit of the industrious rumor-mongers at Washington, who are always ready to furnish a sensational story to order. Mr. Stevens is an engineer of high reputation and the very last person one would expect to suffer such an attack of swelled head as the above story credits him with. Furthermore, as was stated in these columns months ago, the present plan of contract on which bids are now pending was Mr. Stevens' own work, and was completed by him not six months ago. It is, therefore, not only a calumny but an absurdity to assert that he is now threatening to resign if a contract is let for fear some contractor will share his glory.

The real situation, we have no hesitation in saying, is this: That the responsibility is now placed upon the Canal Commission, with the Secretary of War and the President, to decide whether it is on the whole better to accept the low bid of 6.75 per cent. made by the Oliver-McDonald combination, or the high bid of 12½ per cent. made by the McArthur-Gillespie combination, or to reject both bids and continue the work by direct employment of labor under the present organization. It is quite within the possibilities that the final conclusion may be to build the canal by direct employment of labor, and the conclusion will be governed, we feel safe in saying, by much larger and more important considerations than the question whether one man or another is to have the glory for the work.

It is probably a fair estimate that apart from expenses of sanitation administration and engineering and the purchase of materials, about $70,000,000 more will have to be spent at Panama to complete the canal. On this basis the Government would pay $4,725,000 to the Oliver combination for its services in conducting the work, or $8,750,000 to the McArthur-Gillespie combination. Both these sums might be largely increased if premiums for economy in expense and in time are earned. The question is what the Government would receive, under the conditions of the contract in return for its payment to the contracting organizations. When this question is carefully studied it appears that it all narrows down to this: How much better can the contractors do in organizing and directing the workmen than can be done by the Government's own engineers? Under the conditions of the contract, that is all there is left for the contractor to do.

The situation is absolutely and wholly different from that presented in an ordinary contract letting. When a railway company lets a contract for a bridge or a large embankment, it lets the work to a concern which is accustomed to doing just that class of work, and has the plant and tools and organized and experienced force to do it. The contractor can procure his materials, assemble his plant and working force, provide for feeding and housing them and coordinate all the various parts of the work far more expeditiously and economically than the railway company can. At Panama, however, the Government engineers have already done this difficult part of the work, for which the employment of a contractor is ordinarily advantageous. They have assembled the working plant, have provided for housing and feeding the working force, have brought together great stores of material and supplies, and have provided for the sanitation of the works and of the whole Isthmus. These departments of the work, moreover, will for obvious reasons continue under direct control of the Government even if a contract is let. The question recurs therefore: How much can the contractor save for the Government, in money or in time, prosecuting the work with the same plant and doubtless with the same labor which the Government is using?

It is unfortunately true that the sensational articles and absurd criticisms published in the daily press have given a large section of the public the idea that Panama matters are being bungled. Some of these criticisms originate from parties who are disgruntled because their own pet plans and ideas have not been adopted, and consequently everything which is being done is wrong. Other criticisms, probably, are due to a desire to make political capital by the opponents of the administration. Still other misleading reports are due to pure sensationalism—the newspaper demand on its Washington correspondents for something regarding Panama that will make a scare headline.

Then there are the well-meaning critics who cannot see why this is done or that is not done to suit their own ideas. To give one instance, by way of illustration: we hear it said that the contractor ought to be allowed to purchase the materials instead of having the Government engineers do this. It is argued that a contractor can cable for needed material and get it forthwith, whereas the Government has to go through the routine of advertising for and receiving bids, etc. Admitting this argument without comment, let us look a little further ahead and see what kind of a hornet's nest would be stirred up if the contractor bought the cement of the A. B. C. Co. when the X. Y. Z. Co. and several others would have been glad to furnish it at a lower figure! How the charges of graft would fly and how the Congressional investigating committees would hustle to make political capital! One does not have to canvass the possibilities far to see that a contractor spending Government funds for material would have to go through about the same process that is now followed, in order to protect himself, and protect the public interests as well. And even when he did, there would still be inevitably a constant cry that the contractor was being enriched by improper and dishonest perquisites.

It can easily be foreseen that no matter who receives the contract, there will be a whole army of vociferous critics to denounce the Government all through the course of the work for enriching the contractor and the capitalists associated with him. It is doubtless foresight of such difficulties ahead that impel the Government to weigh the whole situation carefully before finally putting the work under contract.

The common sense of contract-making must be invoked to settle a doubt brought before us by W. N. F., of Berkeley, Cal. The subject of the question is one upon which clear ideas are so essential that we take space here for a brief discussion, on the chance that it may be of service to others besides the questioner. The letter of our correspondent is as follows:

> In making payment for cast-iron, is it customary to accept shop weights or to figure volumes from plans? I have in mind a general contract in which a large amount of cast iron was called for. The contractor contended that as he bought the iron by weight he should be paid by actual weight. The specifications were silent on the point and the case was settled by compromise; but the original contentions of the two parties were quite diverse. What is the general practice? Also, what is the general practice covering the same point (1) for ordinary structural shapes; (2) for built-up members?

Both castings and steel work are sometimes bought under a lump-sum payment contract, but more often under a pound-price contract. For structural steel work, especially large or complicated jobs, it is now by far the more common to ask for bids per pound. Castings are almost always contracted for on a price-per-pound basis. Steel shapes, like other raw material, are always bought and sold by the pound (or ton).

The case of a contract for cast iron cited in the above query refers to a pound-price contract, we presume. If not, that is if a lump-sum bid is involved, and the contractor attempted to put in a bill for extras because of difference between actual weight and estimated weight, his claim is to be viewed as an attempt at extortion, unless the extra weight were due to changes from the contract plans, changes either ordered or authorized by the buyer.

But the query seems to imply a pound-price contract. In this case the general principle is applicable that a buyer pays for the quantity he buys, not for a fictitious estimated amount, unless the latter (or some other definite measure) is specified to be the basis of payment, (which of course converts it into a lump-sum contract.) A drawing for a casting does not define the article of purchase, but merely defines the shape and dimensions desired; both buyer and seller well know that the casting cannot conform exactly to the lines and dimensions laid down, and that its weight cannot agree exactly with the estimated weight. Their contract was made for "XX lbs. castings, as shown by plans —— ——, at —— cts. per pound." When the invoices and check weights show that the castings delivered exceed this estimate of XX lbs. by, say 3%, and when the purchaser accepts these castings as being the articles specified, he tacitly concedes that the amount of XX lbs. was only a theoretical approximation, and that the fulfilment of the contract necessitated the delivery of a weight 3% greater. The specified price per pound is evidently the price per pound of castings, not per pound of estimate.

The case is precisely the same as that of paying for excavation by the cubic yard. The result (a trench, for example) is defined in the contract, and the contractor is held to produce this trench by excavating XX cubic yards at so many cents per cubic yard. If it is not possible to complete the desired trench by excavating only XX cubic yards, then payment must be made for the increased excavation necessary. The essential purpose of the contract is the trench, not the excavation of a specified number of cubic yards; and if the specified quantity is incompatible with

particles of iron from the brake shoes. All of these are disagreeable and probably injurious to health.

Another matter, at times perhaps more disagreeable and injurious than either of the foregoing, is that of the rise of temperature in subways caused by the conversion of a large amount of electric energy into heat. As far as the writer is aware, no particular attention had been given to this question until the summer of 1905 after the opening of the New York subway. The most obvious remedy for annoyance caused by the fine dust, iron, and oil, and the rise of temperature referred to, is a judicious use of an ample ventilating system.

Regarding the cost of subway ventilation at Boston Mr. Carson says:

A very rough estimate for the Boston system places the total cost of the ventilating construction, including chambers, ducts, fans and motors, at $125,000, or less than 1% of the combined cost of the original subway, the East Boston tunnel, and the Washington St. tunnel. An equally rough estimate of the cost of operation, including power, depreciation, attendance, and interest on first cost, for ventilating the combined system is $14,000 per annum. This will probably be less than 1% of all costs of operation and interest.

The cost does not appear to be prohibitive, and considering experience up to the present time it seems fair to say that electric subways with dense passenger traffic should have the means, and the means should be freely used, for complete positive ventilation.

Mr. L. H. Woodbridge, in discussing Mr. Carson's paper, gave the following, regarding the advantages of ventilating subways, as at Boston:

Several methods for ventilating the original subway were considered, one being that proposed by an alien engineer who advocated it as a sure, if not the only "positive" method. The method proposed was the reverse of that employed for ventilating the Liverpool-Birkenhead tunnel, namely: a properly proportioned airway built parallel with, and in close proximity to, the subway, with suitably spaced and dimensioned openings between that airway and the subway; the air to be supplied to the airway by a blower placed midway between stations, and the airway extending from that midway point in each direction toward and nearly to those stations. It was proposed by that method to secure a controllable distribution of fresh air along the entire length of the subway.

The method was not approved for reasons of cost, both of construction and of operation, and also because of inefficiency in the supply and the unsuitableness of the use of air in ventilating work. The cost of constructing an airway, say four feet in diameter and nearly the entire length of the tunnel, and of connecting that airway at frequent intervals with the subway, would have been large. The power expended in moving, let us assume, 450 cu. ft. of air per second through each of the two branches of such an airway, each branch being some 600 ft. in length, would be excessive as compared with that required to move the same quantity of air through the same length of the subway having a cross-section of 450 sq. ft. In the case of the airway, the pressure required would be approximately 4.28 lbs. per sq. ft., which multiplied by the area of the 4 ft. diameter airway (12.56 sq. ft.), and that again into the per minute lineal flow (2,160 ft.), would give a total of 116,021 foot-pounds per minute for each half of the airway between stations. The same air quantity per minute moved through the subway itself would require the very low pressure of 0.0008-lb. per sq. ft., which, multiplied by the area of the cross-section of the subway (450 sq. ft.), and that product by the per minute lineal velocity of flow (60 ft.), gives approximately 20 foot-pounds per minute as the frictional work; or approximately one five-thousandth of that work found for the special airway method of ventilating a subway. As one of the principal costs of such ventilation is that of the power required to operate ventilating mechanism, that enormous disparity in work to be done by such mechanism in the two cases made it quite impossible to favor the special airway scheme from the standpoint of operating economy.

As to the efficiency of the airway method of supplying air to the subway, it will be observed that the entrance of equal volumes of air at intervals of, let us suppose, 100 ft., would normally result in a cumulative movement of air from a point midway between the stations toward and to those stations. Each of the six 100-ft. sections of the subway would then receive a supply of 4,500 cu. ft. of air per minute. If the impurities which vitiate the air of the subway are assumed to be equally generated along its length, the impurity held by the air of the successive sections from the center to the stations would be uniform, and the air encountered by those entering the stations from the outside would be that carrying the impurity out from the subway through the stations and approaches for outboard discharge. The result would then plainly be a uniformity of atmospheric vitiating contents throughout the subway and stations, and approaches to stations.

Some of such contents would be taken up by the air within a few feet of the point of discharge, and some of it 600 ft. distant from that point and requiring ten minutes of travel to reach the station, having passed through the six intervening sections between the center and the station point, a condition to be presently noticed as one to be avoided. The longer the distance traveled, the longer the time of retention of the organic matter in the air, and the greater the change toward fermentation and decomposition, and the more offensive the attending odor. A movement of air from center toward stations would therefore bring to the stations and approaches the worst of the subway air.

In the matter of protection against dangerous situations, as those incident to fire or panic, the method of ventilation by auxiliary airway supply is as faulty as it has been shown to be in its mechanical features. In the case of the firing of a car within a subway and between stations, the natural rush of escaping passengers would be toward the stations. If the air traveled in the same direction with those in flight, escape from smoke and heat would be less immediate and complete than if the air moved in a counter direction.

So also for the prevention of panic at crowded stations, due to a filling of those stations with smoke and heat consequent upon the accident of fire within a subway, an indraft of fresh and cool air from without is to be preferred to an outdraft at those congested points of smoky and heated air from within.

A further reason which favors the entering of air at the stations and the removing of air at points midway between stations, is that the air of the subway most breathed is that at the stations by the waiting crowds. Once in the car, if it be of the closed type, the air breathed is that of the car rather than of the subway proper. Furthermore, the change of air within closed cars is chiefly at stations, when doors are open and the passengers are in exit and entrance. The quality of air at the stations is therefore of more vital importance than is that of the subway except when open cars are in use.

The maintenance at the stations of the purest air practicable is additionally advisable because of the impression made on most users of the subway by the quick transition made from the outer to the inner air on entering the stations and when the olfactory senses are keen, and any taint in the air entered is quickly detected. If on entrance the air is noticed as repulsive, a mental impression is made which is likely to be persistent, and to magnify and aggravate such defects as actually exist, and to find expression in private and public criticism and condemnation of atmospheric conditions in the subway.

Therefore, for the maintenance of the better hygienic conditions in the subway; for the more effective use of air; for the protection of patrons in case of fire; for the prevention of panic at stations; and for the subordinate effect of insuring favorable first impressions on the users of the subway, the intake of air has, in the Boston instance, been made at the stations and the discharge at points midway between them.

In general, the minimum quantity of air [illegible] the mechanical system for the ventilation of the subway is planned to move is, as has been stated by Mr. Carson, equal to a flow of one linear foot per second from each station toward each center of discharge. The maximum speed of the fans was planned to be such as to discharge 50% in excess of the minimum quantity assumed. If the cross-section of the subway is 450 sq. ft., the minimum per minute air flow through the discharge ports, or fans, between stations should be 54,000 cu. ft., enough to supply 1,000 breathers with such reasonably pure air as to give a carbon dioxide increment of less than 6 parts in 10,000 of air. If a rise of five degrees of temperature be allowed, due to the transformation of mechanical into thermal energy, the corresponding rate in horsepower of work so transformed would be 115 between stations. Allowing an average electric input of 100 H.P. to each car, eleven cars continually running between stations located 1,200 ft. apart would be provided for.

TABLE SHOWING THE VITIATION OF AIR IN BOSTON'S SUBWAY, HALLS, THEATERS, CHURCHES, SCHOOLS, ETC.:

	Parts of Carbon Dioxide in 10,000 Volumes.	Remarks.
Boylston St. station, 5 ft. above southbound platform.....	9.45	Samples taken between 5 and 5.30 p. m., on week days in January and February, 1899. One of the fans in the West St. chamber is believed to have been running when the third sample was taken. In the other cases none of the fans were running.
Midway between the Boylston St. station and the Winthrop school ventilating chamber	6.53	
Park St. station, 5 ft. above the southbound platform	7.78	
Adams Sq. station, 5 ft. above platform..	6.62	
Haymarket Sq. station, 5 ft. above northbound platform	9.13	
On the street in the central part of the city	4.5 to 5.9	Made at about the same time of year.
In the center of a car on Boylston St. about to enter the subway	24.97	Sample taken about 8.30 a. m., February 25, 1899, and car contained some 65 passengers. Rear door was opened once or twice while sample was being taken. Forward ventilator was closed and rear ventilator open about ½-in. Weather clear and cold.
City Hall Council Chamber, ⅛ full....	Floor 10.12 to ..... 14.00 Gallery 13.22 to 18.58	
Large public hall in Boston, near open door, with in-draft..	13.93	
Another hall in Boston, well filled...32.59 to	36.43	(the latter being in the gallery.)
Four of the principal theaters in Boston	16.16 to 48.7	
Two large churches, Boston and Brookline .....12.45 to	18.19	
Twelve schools in Boston, Cambridge, Chelsea, etc...7.1 to	23.50	

ELECTRICITY IN IRON AND STEEL METALLURGY.*

By R. A. HADFIELD, M. Inst. C. E.

There are those who look forward to an electrical method of producing iron and steel. If any practical system of this nature for converting iron-ore into pig-iron or steel could be introduced, using the stored-up powers of Nature instead of burning carbonaceous fuel, the revolution in practice would be great. Probably more than one hundred million tons of coal, equal to about one-seventh of the world's total output, are used annually in the smelting of iron, to say nothing of the further large quantities employed in the subsequent working of iron and steel into more finished form. Where water-power and suitable iron-ore can be found together, no doubt, satisfactory electrical smelting practice will be developed, but this can only come slowly.

Pioneer work is being done in Sweden, France and Canada, in electrical smelting for the production of steel, but unless water-power can be obtained at economical rates it would seem that the application of this system must remain very limited; that other sources of power should be used at present appears to be out of the question from an economical point of view. Moreover, the electric furnace does not purify steel more than other furnaces not specially adapted to that purpose. Bad steel can be produced by it as easily as by the ordinary processes. Some of us know how often the old type of crucible-steel melting, so largely practiced in Sheffield, has been threatened with extermination, but more material is now produced in this way than ever before. The electrical system has in this older method, notwithstanding its extraordinary wastefulness, a competitor that will not soon be annihilated. There is no magic in the electrical method as it would almost seem some would have us believe. Steel made by it shows similar analysis, and has the same physical qualities as that produced in other ways.

An important question in connection with electric furnaces is, whether they can ensure uniformity of temperature. It is well known that they are apt to produce steel which is much colder at the top of the molten bath than underneath; this is, of course, objectionable. Of the many failures with electric furnaces we hear little; it would be interesting to know more about them. I say this in no disparagement of a "young" process, but to prevent the uninitiated being dazzled by the mere term "electric."

It is stated that the efficiency of the electric furnace is already comparatively high, say 50%, but under present conditions it would still be more expensive to develop heat, at any temperature within the range of a coal-fired furnace, by electricity than by coal; that is, if electricity has to be generated by steam-power, even with plant of the highest efficiency.

The electric furnace has a range of temperature of about twice that of the ordinary steel furnace, so that it will extend up to about 3,000° C. Reactions which take place within certain limits of temperature as now practiced may be reversed at the higher range made available by the electric furnace.

MUNICIPAL OWNERSHIP OF WATER-WORKS at Portland, Me., is contemplated by a bill introduced in the State Legislature providing for the incorporation of the Portland Water District. The district would include, besides Portland, the cities of Westbrook and South Portland, and the district would be authorized to supply water in addition to Standish, Windham, Cape Elizabeth and Scarboro. If the bill becomes a law the proposed district will be authorized to purchase the property of the Portland Water Co. and the Standish Water & Construction Co., which, we understand, supplies all the municipalities named above.

*Extract from the "James Forrest" lecture before the Institution of Civil Engineers on "Unsolved Problems in Metallurgy."

Among the excellent laws which the Congress passed at its last session was an employer's liability law. It was a marked step in advance to get the recognition of employers' liability on the statute books, but the law does not go far enough. * * * Compensation for accidents or deaths due in any line of industry to the actual conditions under which that industry is carried on should be paid by that portion of the community for the benefit of which the industry is carried on—that is, by those who profit by the industry. * * * It is therefore clear to my mind that the law should place this entire "risk of a trade" upon the employer.

This is no warrant for such legislation upon any principle of natural justice. The argument is not that such a law is just, but that it is necessary; that the deplorable number of casualties arising in the relation of employer and employee imperatively demand, as a matter of public policy, to prevent pauperism, to save the maimed and crippled from becoming a public charge upon the state that the burden should be placed upon him who can best sustain it, that is, upon the employer.

Before this federal statute, so heartily approved by the President, was six months old, and within thirty days from the delivery of the President's message, the law was declared by two circuit courts of the United States to be unconstitutional.*

Referring again to the suggestions of the President of the United States contained in his last message, we find the following recommendation:

> If the entire "trade risk" is placed upon the employer, he will promptly and properly add it to the legitimate costs of production, and assess it proportionately upon the consumers of his commodities.

Here we catch the first glimpse of a great idea. He would make the employer of labor in the United States an insurer of the safety and of the lives of his employees. He would ignore the cause of the casualty and would have the employer make compensation for injury or death, whether the accident resulted solely from the negligence of the unfortunate person, or from the negligence of another workman, or from the master's negligence.

This proposition is not so startling as at first blush it appears. If the President had gone farther in his recommendation, and had suggested a fixed scale of indemnity, reasonable in amount, and graduated according to the extent of the injury, or in case of death, determinable by the decedent's earning capacity, so that the employer thus made an insurer might know the exact extent of his liability, so that he might in all instances insure against it and tax the amount of premium he pays to the trade, he would then, in effect, have recommended the adoption in this country of that policy and practice, which has for many years been adopted and enforced in many of the countries of Continental Europe.†

*It should be noted that the decision in this case has been appealed to the Supreme Court of the United States, and that Attorney-General Bonaparte has been granted permission to appear on behalf of the Government to defend the constitutionality of the lawreferred to.—[Ed., Eng. News.]

†In Norway and Sweden the government insures all workmen against accident or death. The premium is paid by the employer, but the expense of administering the insurance department is defrayed by the state. The amounts paid are based upon a percentage of the last yearly wages earned by the injured or deceased person. These benefits are paid so long as the disability, either partial or total, continues. The percentage varies in proportion to the severity of the injury. In case of death the widow gets 60% of the last annual wages for life, and each child under 15 gets 15% until it reaches that age. The employer is not permitted to deduct the premium he pays from the employees' wages, but he has, doubtless, long since anticipated the advice of President Roosevelt, added it to the cost of his product, and taxed it to the trade.

In Switzerland, while the government has not gone into the insurance business, it compels an employer of labor to take out accident insurance for his workmen, and the premium may not be deducted from their wages.

In Germany the government requires that all those manufacturers engaged in a certain line of production shall stand the entire risk of the injuries or death to employees engaged in any of the plants where those lines of manufacture are carried on. This risk must be insured against, and the insurer graduates the premium in proportion to the relative risks in the different plants. Thus all workmen are insured. For all total permanent disability, two-thirds of the last annual earnings are paid for life, and proportionately less for partial temporary or partial permanent disability. In case of death 60% of the annual wages go to the widow for life, and 20% for children during minority.

In France there is a fixed scale of prices to be paid, but insurance against those risks is optional with the employer. The government enjoins: first, the payment of all medical and funeral expenses; second, commencing with the fifth day after the accident for temporary incapacity, one-half wages during the time of his disability; third, for a total permanent disability, two-thirds of the annual wages for life, and proportionately less for partial, permanent or temporary disability. In case of death two-thirds of the annual wages go to the widow, and 15% for minor children during minority.

Against these risks the employer in France protects himself, either by ordinary indemnifying insurance, or by mutual protective insurance associations organized among the employers, or by insurance in the Government National Accident Insurance Bank. The premiums may not be deducted from the wages, but are undoubtedly added to the price of the article.

In Great Britain, since 1887, payment is compulsory upon railroads, factories, mines, quarries or engineering works. In case of death, not more than the last three years' annual earnings shall be paid to the widow or dependent family, and in no event shall an amount be paid exceeding £300, and proportionately less if the family be not dependent. In case of permanent or partial disability, from 50% of the annual earnings down, but in no case to exceed £1 per week.

It would transcend the purpose and the scope of this paper to give in detail the methods established by law for compensating the injured employees across the water. Suffice it to say, in general, that in Belgium, Norway and Sweden, Switzerland, France and Germany, and of late in Great Britain, legislation is constantly tending to a universal liability of employers for injury or death to the employee, in any of the industrial arts, regardless of the manner of the accident, or whether it resulted from the negligence of the injured party, or his fellow servant, or his employer.

In all of those countries, however, the amount to be paid in each specific instance, whether of injury or death, is graduated and determined by a fixed and unalterable scale, based in general upon a certain per cent. of the previous earning capacity of the unfortunate employee, varying according to the extent of the disability, whether temporary or permanent; or in case of death, by the previous earning capacity of the deceased. The amount of compensation exacted by law of the employer is so reasonable and moderate that, as a matter of general experience, the aggregate amount paid by the employers of labor, under the continental system, is absolutely less than the amount paid by the employers of labor in America, who pay upon the theory that only those who are deserving of compensation shall be paid.

For obvious and sound reasons the application of such a system to the industrial conditions of the United States would be attended by extreme difficulty, if indeed its adoption were at all possible or desirable. In the first place the Federal Government is absolutely without authority to enact or enforce laws of that character.

The individual States alone may legislate upon the subject within their own territorial limits. What reasonable ground for expectation have we that all the States would ever agree to fasten a general liability upon all employers of labor. If by a wild flight of fancy we can imagine that all the states would agree to such a law, who so rash as to venture to suggest the adoption by all of a uniform, limited, reasonable and moderate scale of payments and indemnities in case of injury or death, such as would subserve the purpose of an enlightened public policy without destroying utterly the very fabric of our industrial prosperity! Such a system, in short, as the nations of Europe which really govern, administer with humane results, for their people. What state legislature so deaf to the unthinking clamor of the multitude, so blind to its own political fortune, as to stand against extortionate demands for high and ruinous rates of compensation?

The reasons which Mr. Wilson cites seem to us neither obvious nor sound. The system which President Roosevelt has lent the weight of his high authority to advocate has been for many years in successful operation in all the other leading industrial nations of the world. If our form of government is so hopelessly bad that such a system could not be adopted here, one might well despair of democratic government.

Let us rather look at the matter squarely and fairly and admit that the reason why this great and important extension of employers' liability laws has been adopted in European countries and not adopted here is that not democracy but privilege has ruled in American law-making bodies.

Nine-tenths of our legislatures are composed of lawyers and our present laws covering liability of employers are eminently adapted to benefit the legal profession. In the above address it is stated that the total payments for accidents to employees are larger under the American system than under the European system. We do not question the truth of this; but under the American system the bulk of the payments for damages go to the lawyers. If one could have as a relief fund the entire amount paid out in litigation over accidents to employees in the United States, plus the actual payments by employers in successful damage suits, it would be sufficient to effect relief of all sufferers from industrial accidents on a scale more generous than that of any European country. In addition it would give a vast measure of relief to our overcrowded courts and bring satisfaction to tens of thousands of litigants in other cases now suffering the law's delay.

In the address above quoted, we are told that "the employers of labor in America pay upon the theory that only those who are *deserving* of compensation shall be paid." We venture to say that no one knows better than the railway attorneys who defend damage suits that this is merely a theory and that the practice is something entirely different.

The practice is to contest all claims of employees for damages except in the rare cases where the employer's negligence is so clear that the outcome of a trial is certain. Such cases may be compromised. Whether an employee is "deserving" of compensation or not is never considered. It is whether he can win his case in court. In the conduct of these accident cases so much sharp practice is indulged in by the attorneys for both sides that this department of law has come to have a bad name even in the legal profession.

The ultimate outcome is that the employer is mulcted in very heavy damages for one out of a dozen or a hundred, perhaps, of the accidents that occur among his employees. The lion's share of these damages goes to pay attorneys and experts' fees; and the actual sufferer by the accident gets only a small slice. All the rest of those who suffer accident and those dependent on them bear their burden of loss or want unrelieved, except by private charity or public funds.

Is it not manifest that such a system tends to breed pauperism and crime? Is it not clear that such a display of "man's inhumanity to man" puts weapons into the hands of those who would tear down existing institutions and start a warfare of the masses against the classes?

It may be objected that employers' liability laws look only to the payment of compensation to those who suffer by accidents and not to the prevention of accidents, which is the great end to be sought after. The prevention of accident will come about, however, just as soon as the cost of the accident is brought home to the employer. If neglect in guarding his workmen means higher insurance premiums to be paid, he will have a strong incentive to instal safety appliances and remove conditions of danger. The inventor or salesman who comes to him with a meritorious safety appliance will then receive a fair hearing. The cost of accidents will then be brought home, not only to the Manager of a business but to the Directors and stockholders, and it will be realized that it is good business and not merely humanity that counsels the spending of money in safety appliances.

If the Institute for Social Service or the Civic Federation or any other organizations which look to the betterment of industrial conditions can enlist public support for that extension of employer's liability laws which President Roosevelt has so ably championed, they will achieve as great a victory for the cause of human freedom as was won by that great apostle of freedom whose birthday the nation this week celebrated.

LETTERS TO THE EDITOR.

Continuous Beams or Shafts Having Three Supports.

Sir: Noting an article on the above subject in your issue of Oct. 11 last from the pen of Mr. E. Wagner, I wish to describe a method I have used for many years which I think is simpler and more convenient.

In most engineering offices is to be found a steel straight-edge. Mine is six feet long. This I place on firm and accurately levelled supports and load it in the manner desired, using cast-iron weights of 1 lb. each, of which I possess a considerable number. Then by means of an accurate spring balance I find the force necessary to just lift the straight-edge off each support, or if it tends to lift of its own accord the pressure needed to hold it down. Thus I obtain the reactions from which the bending moments and shears are easily computed. If I desire to be very exact I repeat the experiment, reversing the straight-edge end for end and turning it upside down, and take the mean of the results, and also count in the weight of the bar itself in reckoning the load.

I find this method works very well for any ordinary arrangement of three supports; also if very carefully performed for four supports.

I would point out that both Mr. Wagner's method and mine fail if there is a crank in the shaft. A crank greatly increases the flexibility of the part of the shaft in which it occurs, approaching remotely in effect to a hinge. The result is that in the three-bearing two-crank arrangements discussed by Mr. Wagner nearly the whole pressure comes on the central bearing and hardly any on the end ones, so that the heating of the central bearing is not to be wondered at.

Yours very truly,
W. C. Kernot,
Professor of Engineering.

University of Melbourne, Melbourne, Victoria, Jan. 1, 1907.

the essential purpose, then the latter governs in interpreting the terms of the contract.

Of course, payment for work at unit prices leaves the danger that the contractor may carelessly or purposely increase the quantities of the work, for his own gain, and claim that the increase was unavoidable and was necessary to the proper performance of the contract. On this account it is customary, we may say universal, in large contracts to specify the maximum amount of excess for which payment will be made. Thus, a lot of cast-iron column bases is required, built to complete drawings, and the bid is to be per pound; then the contract will specify that the payment will be made on the basis of actual aggregate weight up to an amount exceeding the estimated weight by say 4%. Similarly, contracts for excavation will specify that payment will be made for all the actual excavation that lies within limits say 12 ins. outside the neat lines of the cross-section.

In the absence of such a limitation on the excess quantity, the contract would bind the purchaser to pay for the actual quantity of work performed or furnished, unless he could show that an unreasonable increase of quantities had taken place. This would be hard to show, and his (or his engineer's) acceptance of successive portions of the work would be strong prima facie evidence that the work done was necessary and proper.

A question in the same field, but turning on a different point, is put before us by a contractor who furnished certain structural steelwork at a pound-price. The work furnished could not well be weighed, and was not weighed. The contractor rendered a bill based on the weights per foot of the various sections used as given in the mill handbooks, and to the weights of the shapes and plates he added the weights of the rivets used. Now the question is this: Shall the bill include the weights of the rivets, or the weights of only the rivet-heads; that is, shall deduction be made for the punchings?

Like the other question, this one involves only a small item, a small percentage of the total price, but a large percentage of the contractor's margin. But unlike the other question, no simple answer is possible. Perhaps an answer can best be evolved from the general principle that, in the absence of a contract clause defining the method of determining the weight, customary practice must govern. How do steel contractors customarily figure their delivered weights of billing, when direct weighing is not practicable? If this question cannot be answered readily, then let us ask: How do steel contractors usually figure the weights which they use in making a bid on the work? We think it will be found that a lump-sum bid is frequently based on weights which include the whole rivet weight and contain no deduction for punching. Pound-price bids more often are based on no accurately computed weights, but only on approximate estimate, or merely on the character of the work. Did the contractor in this case make a detailed weight-estimate before bidding? If so, and if this weight-estimate included the full rivet weight, he could submit the estimate in evidence of his good faith in charging for the rivet weight; and this good faith would be an important reliance, if established. The further showing that it is customary practice among steel contractors in making estimates of steelwork, to figure the entire rivets and make no deduction for the punchings, would practically prove his contention.

It is fair to consider, in this case, that since the actual weight of the manufactured work was not determined, the contractor loses the benefit of whatever overweight there might have been in the sections used. It is more probable on the whole that the individual lengths of shape and plate steel exceeded their listed weights per foot than the contrary. The general rule that a pound-price is to be applied to the weight furnished rather than the theoretical weight (and consequently that deduction for the punchings should be made) is here modified by the fact that in the absence of actual weighing the contractor loses the advantage of the probable overweight of sections, and therefore should not be put to the further disadvantage of allowing credit for the weight of punchings at the unit-price of rivet steel.

HOW CAN WE SECURE SAFETY FOR WORKMEN?

We read with dismay the blood-stained chronicles of our national history, of carnage, slaughter and white up-turned faces in the wake of battle, and humanity is moved to compassion; but verily the tragedies of peace, though less dramatic, are more profound than the sacrifice of war.

During the past four years the total number of fatalities in the army of working men upon railways, in factories, mines and elsewhere in the United States, exceeds by many thousands the deaths on battle field and hospital in both the Union and Confederate armies during the four years of our Civil War. Not Gettysburg, nor Chickamauga, nor the bleaching bones of the Wilderness, compared in pathos with the opening years of this century.

The world was startled by the tragic loss of life upon the "Maine," but every day of the year more lives are lost by accidents in the peaceful pursuits of industry in this land. Eleven hundred employees will be killed next week, and the next, and the next, to the end. The wheels of our vast material prosperity roll over them, even as the car of the Juggernaut, and the silent army vanishes unwept, unhonored, and unsung.

On Jan. 29 there was formally opened in New York City an exhibition of safety appliances and inventions designed to reduce the number of accidents to workmen. At a dinner given to celebrate the opening of this exhibition, the President of the United States sent a letter signifying his hearty approval of the movement; the Governor of the State of New York was the guest of honor, and the representatives of many large industrial concerns were in attendance.

The exhibition and the dinner celebrating its opening were organized by the Institute for Social Service, a philanthropic society of New York City, whose president is Dr. Josiah Strong and whose secretary and active executive officer is Mr. William H. Tolman.

We can conceive of no greater social service that any organization could perform at the present day than to effect a substantial reduction in the risks to life and limb and health undergone by the members of the great industrial army. No one doubts the figures of enormous fatalities. No intelligent engineer, at least, will question that a large percentage of the accidents in industrial life could be prevented. The question is, how can the reform best be brought about.

We would say no word in criticism of the Institute or its plans; but with a desire to aid in reaching the desired end, we venture to express here a frank doubt whether either the present exhibition or the proposed permanent museum of safety appliances which the managers of the institute wish to establish will have any large influence in bettering industrial conditions and lessening the present terrible waste of human lives and limbs in our industries.

Those engaged in active business affairs are as a rule too busy to attend exhibitions or study museums, save possibly in a hurried and cursory way. Furthermore, it is practically impossible to collect in an exhibition or museum a really up-to-date presentment of the state of an art. Changes come too rapidly in these strenuous days. As an actual fact, one finds any exhibition nowadays filled chiefly with old and well known devices. There may be a sprinkling of impracticable inventors' models, but only here and there does one find an occasional novelty of real merit and importance.

It is not by such exhibitions that changes in industrial methods are brought about at the present day. The manager of a mill or a factory or a mine does not go to an exhibition or a museum to find out how to protect his workmen from accident. Other educational agencies—the technical school, the technical society and the journals devoted to special arts and industries have taken the place of the exhibition. It is to such agencies that we must look to dispel the ignorance and the conservatism that is, in the last analysis, the chief cause of loss of life and limb in the casualties of industrial life.

The work of the Institute in connection with the present exhibition is valuable because of the publicity which it is giving to this important and too much neglected subject. To call the attention of ten thousand captains of industry to their responsibility for safeguarding the lives and limbs of their employees—that were a social service well worth the doing.

If, however, society is really to cope with this enormous evil—if we are to really and permanently reduce the loss of life and limb that now constitutes a national disgrace, we must do something more than merely spread before our factory managers an exhibition of safeguards for their workmen or excite these managers to a spasmodic interest in their employees' safety.

In Gov. Hughes' speech at the dinner above referred to he declared in emphatic terms that the provision of safety for workmen was not an act of charity but of justice. He denounced the legal fiction by which an employee is assumed to take the risk of the work in which he engages, when as a matter of fact he has to take the work as it is offered to him or accept the alternative of idleness and starvation.

That some moves are being made toward better things is fortunately true. A considerable body of law is now on the statute books requiring employers to do something in the way of sanitation, ventilation and the protection of machinery. We shall not be on a right basis, however, until we follow the lead set by European nations and place the burden of responsibility for industrial accidents where it justly belongs—upon the industry itself.

In all other great industrial countries except the United States it has come to be recognized that casualties of a greater or less amount are an inseparable accompaniment of industry and that justice demands that the industry itself should bear the burden of these casualties. Under American laws, an employee who under the stress of necessity, perhaps to save his family from starving, accepts work in a risky occupation, has only a sentimental claim on his employer in case he suffers accident. Under European laws, such an employee or those dependent on him are paid a certain definite amount, proportional to the wages he was receiving and the extent of the casualty.

The practical effect of this law is first to relieve a vast amount of suffering and destitution which otherwise would result in the families of wage earners stricken down by accident, second, to greatly reduce the number of such accidents. The general practice is of course for manufacturers and others to take out insurance against accidents to employees, and charge up the insurance premiums as part of the cost of carrying on the business as they do their fire or boiler insurance. The expert inspectors of the underwriters then see to it that mills are equipped with proper safety devices for employees' protection.

The quotation at the head of this article may be thought by some readers to exaggerate the casualties in industrial life. It may be supposed to be the statement of some humanitarian enthusiast, and to be therefore subject to some percentage of deduction. The quotation, however, comes from no such source. It constituted the opening sentences of a recent address by a railway attorney, Mr. James P. Wilson, whose business it has been to fight damage claims for injuries to employees and whose address, before the Pittsburg Railway Club, was in opposition to any extension of employers' liability laws.

While this was the attitude of Mr. Wilson, his address contains so much of interest with reference to this subject that we make the following further quotation:*

> In June last, Congress enacted a law providing that the fact that an employee was injured or killed solely by the negligence of his own fellow workmen should constitute no defense by the railroad company in a suit for damages.
>
> This was followed up by the President of the United States in his last annual message to Congress, in which, we find the following forcible expression:

*The complete address was printed in "The Railway Review" of Feb. 2.

WATERPROOFING CONCRETE AND MASONRY.*

By EDWARD W. DeKNIGHT.†

(1) No waterproofing, especially for difficult and waterpressure work, should be undertaken when the temperature is below 25° F. Fifty per cent. better work can be done when the weather is warm. In cold weather the felt sheets are difficult to handle, the hot bitumen-cement chills and congeals too quickly, especially when it comes in contact with a cold wall, and it is difficult to obtain the perfect cohesion of the different felt layers.

(2) Allow sufficient time, room and accommodations in which to properly apply the materials. The reverse of this rule, however, is the common practice. No matter how conscientious a workman may be, he cannot, for example, do good work on a wall, from the outside, if the excavation is not wide enough from the wall to give him room in which to work, or on the inside of the wall if he has scarcely light or arm room, and is crowded upon by workers in brick, in cement, in stone, in steel, etc.

(3) Design the structure to properly receive waterproofing.

(4) Specify always that the waterproofing shall be done only by experienced and skilled labor. Roofing, for instance, is not waterproofing.

(5) Thoroughly protect the waterproofing during and after application. The average laborer is no respecter of waterproofing, especially an elastic waterproofing, and will walk on same, roll wheelbarrows over it, throw tools, lumber, brick, stones, cement, and debris thereon, to its serious damage. After arches are waterproofed, it is a common mistake in placing the fill, not to begin same at the base of the arch but to dump the fill on the crown. The fill thus often breaks through the brick or cement protection on the waterproofing, and tears or strips the waterproofing from the arch surface. It is best to permanently protect waterproofing with a layer of brick or cement mortar.

(6) Inspect waterproofing at all times during application. See that the materials as specified are used, and also that they are themselves up to standard; that the work is done carefully and skillfully, particularly in the out-of-the-way small, difficult places; that the laps are not made 22 ins. when they should be 24 ins.; that the hot cementing material is applied not one-fourth or one-half, but the entire width of the lap; and that it is applied hot, quickly and thoroughly; that full, clean and well-protected connections are provided; that the waterproofing is well protected at the end of the day's work; that no work is done except in the presence, and by the approval of, the special inspector appointed over the work.

(7) Do not depend on guarantees. The speaker has always contended that a waterproofing guarantee is practically worthless. A roofing guarantee is of value, because the cause of, and responsibility for, leaks, can be easily settled. Seldom, however, is there any recovery had under a waterproofing guarantee. Bonding companies are averse to supporting waterproofing guarantees because of the high risk. It will be found, on close analysis, that bonded guarantees do not, in fact, guarantee. Such, for example, is a bonded guarantee reading, that the structure or surface to which the waterproofing is applied, must remain "sound and stable."

The very purpose of waterproofing is to waterproof the structure or surface in the event of their not remaining "sound and stable." Such a guarantee, of course, means nothing, except that the bonding or other company assumes no risk, but shifts it to the owner of the structure, who himself then guarantees that his structure or wall will not crack or injure the waterproofing. The waterproofing should accommodate itself to the wall, instead of the wall accommodating itself to the waterproofing.

A strong case in point is a recent decision on a waterproofing guaranty by the United States Circuit Court of Appeals, Third Circuit, 144, Federal Report 942. In a contract for the foundation of a building the specifications, after describing the waterproofing materials to be used, stated: "The whole to be made perfectly watertight and guaranteed." On the completion of the foundation it leaked and payment was withheld from the contractor. The contractor contended that he had strictly followed the specifications but was not accountable for the result of the plans. The Court upheld the claim of the contractor.

(8) Do not use a standard specification. Each design must suit the exact conditions, and each specification must exactly suit the design. Using a standard specification results in the customary but very serious mistake of placing the waterproofing details on the contractor. A contractor will apply anything that is specified, and, as a rule, is interested only in getting it applied as quickly as possible. Speed in waterproofing is undesirable and dangerous. The specification as to waterproofing should make the contractor responsible only for the proper application of the materials under the close observation and approval of the engineer.

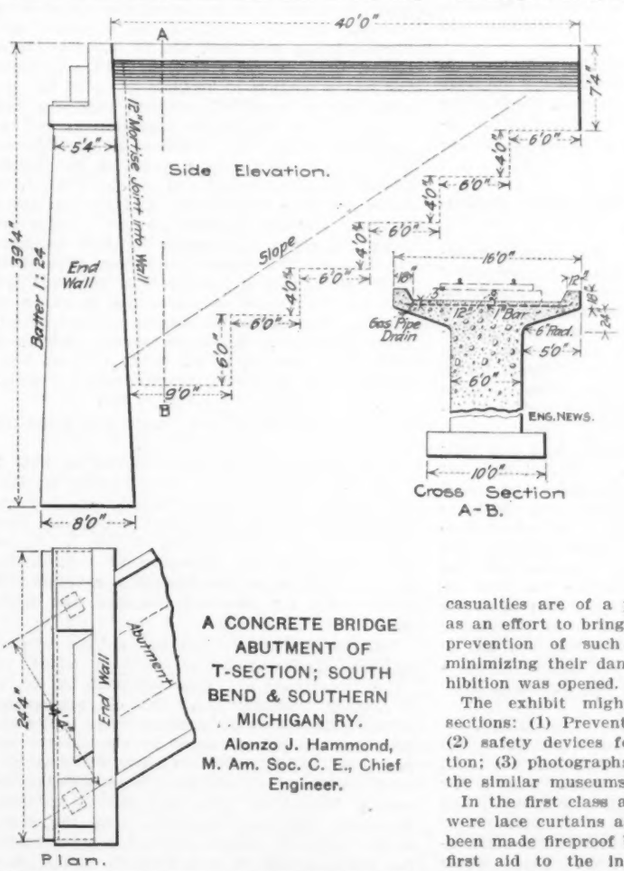
*Extract from a paper read Nov. 21 before the Western Society of Engineers.

†Manager, Hydrex Felt & Engineering Co., 120 Liberty St., New York City.

A CONCRETE BRIDGE ABUTMENT OF T-SECTION.

An interesting design of bridge abutment, of T-section, is illustrated in the accompanying cut, the purpose of which is to effect an economy in concrete and in cost of forms as compared with the ordinary double-wall abutment of U-section. It has been used in the north abutment of the bridge carrying the South Bend & Southern Michigan Ry. (an electric interurban line) over the St. Joseph River near Berrien Springs, Mich., where the conditions were favorable, and it was adopted on the score of economy. The foundation was hardpan, very hard to excavate, and the stepping up of the footings for the stem of the T was readily formed in this material. The bridge has eight Pratt truss through spans of 150 ft. and crosses the river on a skew of 60°.

This form of abutment was designed by Mr. Alonzo J. Hammond, M. Am. Soc. C. E., City Engineer of South Bend, Ind., and Chief Engineer for the railway company. He states that the height is about 40 ft., and that by the ordinary formulas for a retaining wall it would have required about twice the thickness of wall used, while the wings would have been heavy and the footings overlapped. The St. Joseph River bridge is the only case in which the design has as yet been adopted, but Mr. Hammond expects to use it at other bridges where the conditions are suitable, as it presents important advantages. It will be seen that instead of two side walls, there is a single wall 6 ft. thick carrying a cantilevered slab 16 ft. wide, this slab or floor being reinforced by steel bars and provided with drainage holes so as to keep the ballast in good condition.



A CONCRETE BRIDGE ABUTMENT OF T-SECTION; SOUTH BEND & SOUTHERN MICHIGAN RY.
Alonzo J. Hammond, M. Am. Soc. C. E., Chief Engineer.

COLLAPSIBLE STEEL FORMS are being used in building a 12¼-ft. concrete sewer at Baltimore, Md. Mr. Calvin W. Hendrick is Chief Engineer of the Baltimore Sewerage Commission, under the direction of which the work is being carried on.

FIRST INTERNATIONAL EXPOSITION OF SAFETY DEVICES AND INDUSTRIAL HYGIENE.

The American Institute of Social Service has recently inaugurated a campaign in this country against the immense and to a great extent needless loss of life in industrial work of to-day. As a first step toward a betterment of conditions the Institute held at the American Museum of Natural History, New York City, from Jan. 29 to Feb. 12, an exhibition of various devices for the prevention of accidents to workmen and for the betterment of hygienic conditions in factories and workshops. This temporary exhibition is intended to pave the way for a permanent museum of safety devices similar to those which have already been established in Amsterdam, Munich, Berlin and Paris.

The founders of this Institute have investigated the subject of industrial accidents and have reached the very evident conclusion that it is high time some step should be taken toward a prevention of the ever-growing list of accidents in the industrial world.

In the year 1900, according to the U. S. Census Office, 57,513 people were killed by accident or violence. In a recent year 461 fatal and 1,030 non-fatal accidents occurred in the anthracite coal fields. During the fiscal year ending June 30, 1904, there were 10,046 killed and 84,155 injured on the railways of the United States. Of these, 70,699 were employees, of whom 3,632 were killed and 67,067 injured. From the basis of a three-months report from a limited number of factories, the New York Bureau of Labor estimated that in 1899 all the factories in that state showed 14,576 accidents.

These incomplete figures make evident the enormous casualty list of our industrial world, and it is clear that a large portion of these casualties are of a preventable nature. It was as an effort to bring together all devices for the prevention of such accidents or at least of minimizing their danger that this temporary exhibition was opened.

The exhibit might be separated into three sections: (1) Preventive devices for general use; (2) safety devices for machinery and construction; (3) photographs and documents illustrating the similar museums abroad.

In the first class among the principal exhibits were lace curtains and like draperies which had been made fireproof by some chemical treatment, first aid to the injured outfits, non-explosive lamps and gasoline cans, safety awnings, which can be operated from the inside without leaning out of the window, window cleaners' lock straps, elevator locks and portable fire-escapes.

The safety devices for machinery and construction were the most important exhibits shown and the ones which will help most toward reducing accidents. Foremost among these and more generally accepted or used were the various fireproofing and fire-resisting methods and materials. This is one branch of accident prevention to which considerable attention has been paid and which has reached a high degree of efficiency. There were several exhibits of safety stops for engines, one of which automatically shut off steam at any break in steam pipes between boiler and engine, and another which is fastened at each end of the water gage and closes instantly at the breaking of the glass.

In the line of building, several safety scaffolds were exhibited which were provided with special braces fitting into windows, rope attach-

A DESIGN FOR RAILWAY TRACK, BASED UPON A STUDY OF THE STRESSES EXISTING IN TRACK SUPERSTRUCTURE.*

By O. E. SELBY.†

When a bridge superstructure breaks down, we at once make a careful examination not only of the broken parts to determine if defects existed in them, but also of the loads applied and the unit stresses resulting therefrom. We criticise the arrangement of connections and proportions of parts. When a rail breaks under traffic, we conclude that it was piped, and draw morals based on the superior quality of Edgar Thomson 60-lb. rails which last 30 years or so under traffic.

When a bridge pier cracks or begins to churn up and down under passing loads we investigate the live and dead load reactions on it and the depth and character of foundations; then we reinforce it or rebuild it in such a way that it may be made a permanent structure. When a cross-tie begins to churn up and down in the ballast, we simply pack the ballast back under the tie and hope it may not get loose again soon.

When a retaining wall leans forward or a heavily loaded corner of a building settles, we ascertain if the width of the wall at the base is in proper proportion to the height and if the load on the clay under the building is uniformly distributed. When a railway track settles out of level and its clay foundation is forced up between the ties we patiently dig out the clay, get more ballast (if the shovel has not been shut down), and waste our mental energies accumulating statistics on the creeping of rails in the direction of heaviest traffic.

Railway track has grown in strength as heavier loads have made increased strength necessary, but such growth has been entirely along empirical lines and not one single detail of track superstructure bears marks of engineering design. The track, which at the beginning of railways was a detail, has risen to the position of a complex structure carrying the same heavy and destructive loads as the bridges and deserving of the same careful design. Therefore, it seems proper to examine the unit stresses existing under present conditions and, if possible, apply proper unit stresses to designs for a permanent, or, at least, more durable, structure.

The essential parts of a track, aside from the fastenings, are the rails, ties, ballast and subgrade. We may assume as a typical first-class track: 80-lb. rail, with ties 7 × 8 ins. × 8½ ft. long; 20 ties to a 33-ft. rail, on 12 ins. of gravel ballast carrying locomotives with 50,000-lb. axle loads spaced 5 ft. c. to c. Examining first the bending stress in the rail we have 50,000-lb. axle loads on supports 20 ins. apart. For these conditions the American Railway Engineering and Maintenance of Way Association specifications for steel bridges call for 100% impact, making the stresses equivalent to those from a 100,000 lb. axle load or a 50,000-lb. wheel load. For a simple beam the bending moment in one rail would be 250,000 inch-lbs. For a continuous beam with rigid supports it would be 66% of that and for a continuous beam with partially yielding supports 75% of the bending moment for a simple beam is reasonable, giving 187,500 inch-lbs. If we consider the wheel placed over a tie which yields enough to carry one-fourth of the load to each adjacent tie, the resulting moment in the rail is the same. The section modulus of an 80-lb. Am. Soc. C. E. rail is 10.0, making the extreme fiber stress 18,750 lbs. per sq. in. For a 90-lb. rail the unit stress is reduced to 15,600, and for a 100-lb. rail to 12,800.

Passing to the load on the tie we encounter an element which must vary between rather wide limits with the stiffness of the rail and yielding of the supports. With a simple beam and load placed midway between supports, the reaction on each support would be half the load. The theory of the continuous girder would make the reactions about 55% to 67%, depending on whether the load is placed over a support or midway between. The yielding of supports would undoubtedly reduce these percentages. Bridge specifications usually consider the load equally distributed among three ties, but bridge ties are spaced usually 14 ins. between centers, so that, if the load going to one tie is proportional to the tie spacing, the amount for 20-in. spacing would be 47.6%. Therefore, the assumption that the maximum load on a tie is half the axle load seems a proper one. With a 25,000-lb. load on each rail bearing, the bearing per sq. in. on the tie is 625 lbs.

In investigating further stresses in the tie and bearing on ballast some uncertainty as to the distribution of the load effected by the tie is encountered. If a uniform distribution is attained, the load per lin. in. on a tie with an effective length of 100 ins. is 500 lbs., and the greatest bending moment is (at the center) 125,000 inch-lbs. If we consider that the center is not well tamped and that the bearing is uniform over a length equal to twice the overhang or 20 ins. each way from the rail, the resulting maximum moment (under the rail) is the same as before. With a tie 7 ins. deep and with 8 ins. face the extreme fiber stress is 1,920 lbs. per sq. in. If by reason of irregularities of tamping, etc., the bearings become concentrated at the ends or center instead of distributed, the above unit stress may be doubled and result in broken ties. For bearing on ballast, if we take the first and most favorable assumption, we have 50,000 lbs. on 800 sq. ins., or 4.5 tons per sq. ft. If the bearing is only 20 ins. each way from the rail it amounts to 5.6 tons per sq. ft., or an average of, say, 5 tons.

For computing the bearing on subgrade we are furnished a method by Mr. Thos. H. Johnson.* The formulas given are deduced from two premises: (1) That the width of distribution of the load effected by the ballast is equal to the width of the tie plus the depth of ballast for stone ballast or plus half the depth for gravel ballast; (2) that the intensities of pressure within that width are proportional to ordinates to a circular curve whose radius and chord are each equal to the width of distribution. The width of distribution for a tie with 8 ins. face and 12 ins. gravel ballast is 8 ins. + 6 ins. = 14 ins. The same ratio of spread obtains at the ends of the tie, so that the bearing area on subgrade is 14 ins. × 106 ins. = 1,484 sq. ins., and with a 50,000-lb. load the average pressure is 2.4 tons per sq. ft. The maximum pressure is about 50% greater, or 3.6 tons per sq. ft.

All of the foregoing unit stresses except the bending in the tie under favorable conditions and the bending in 90-lb. and 100-lb. rails are far in excess of what would be considered safe or good practice in a bridge structure, and it is not to be wondered at that we have broken rails, cut rail seats, broken ties, loose and pulverized ballast, and clay ridges between the ties. There is no more justification for continuing a small than a large structure in service with higher than allowable unit stresses, except that a failure in the small one may not cause a disastrous wreck; consequently greater risk may be taken. This is the case with all the elements of the track except rail. Hence we repair the failures as they occur and suffer a heavy maintenance expense in order to save the first cost of a better structure.

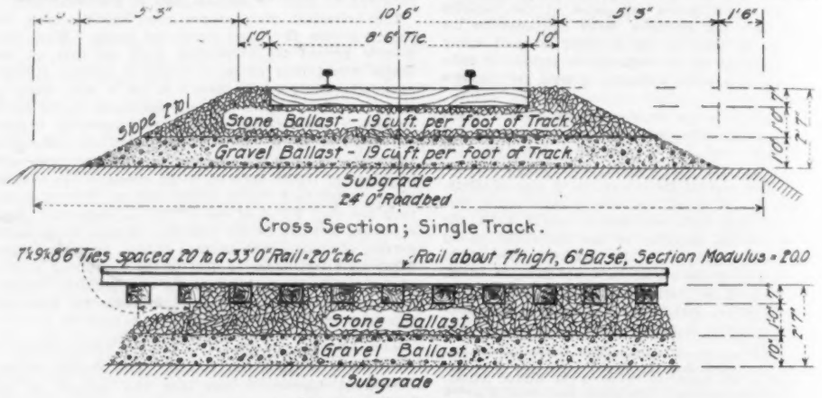
Passing now to the design of a track superstructure which will overcome the defects of the present track we must fix on the loads and unit stresses to be adopted. For these we turn again to bridge practice. Modern specifications call for a loading which contains 60,000-lb. axle loads spaced 5 ft. between centers. The American Railway Engineering and Maintenance of Way Association specifications allow 16,000 lbs. extreme fiber stress on open-hearth steel in connection with 100% impact for spans as short as those we are dealing with. For Bessemer steel only 15,000 lbs. should be allowed. The same specifications allow 2,000 lbs. extreme fiber stress on timber. For bearing on timber (white oak) the United States Bureau of Forestry recommends 400 lbs. per sq. in. For bearing on gravel or broken stone not well confined, 4 tons per sq. ft. is as much as should be allowed. For bearing on clay foundation, subject to frost and usually made ground, 1 to 1½ tons per sq. ft. is good practice.

RAILS.—Consideration of bearing on ballast and subgrade demand that the rail be stiff enough to secure uniform distribution of loads lengthwise of the roadbed. A tie spacing equal to half the wheel spacing would load the girder (rail) at the quarter points and produce moments (in a simple beam) equal to those produced by a uniform load. A more practicable tie spacing one-third of the wheel spacing would similarly produce moments $^1/_{70}$ part or only 1.4% greater than those from a uniform load, so that if we design a rail for a uniform load equal to the wheel load divided by the wheel spacing, the result will be very nearly correct. The wheel load with impact is 60,000 lbs. or 1,000 lbs. per lin. in. of rail. For a continuous beam (indefinite number of spans and loads) the maximum moment is 300,000 in.-lbs. For a fiber stress of 15,000 a section modulus of 20.0 will be required. This is twice the section modulus of an 80-lb. rail and 37% greater than that of a 100-lb. Am. Soc. C. E. rail. It would require about a 115-lb. rail if designed on the lines of the Am. Soc. C. E. section, but the same stiffness could be secured with a 100-lb. rail 7 ins. or 8 ins. deep, similar to the deep T-rail sections designed for street railways. It is important to note that the above design takes full advantage of the continuity of the rail, and hence, would require 100% joints and practically non-yielding supports.

TIES.—Space ties 20 ins. c. to c. (20 to a 33-ft. rail), then the load on one tie-plate (with impact) is 20,000 lbs., and the required area of tie-plate is 50 sq. ins. This is secured by a tie-plate 6¼ × 8 ins.

For the bending of ties, space the ties 20 ins. c. to c. and assume distribution as in previous discussion, then bending moment = 100,000-in.-lbs. A unit stress of 2,000 lbs. in extreme fiber will require a tie 7 ins. deep and 6 ins. face. On account of irregularities in ballasting and tamping this ought to be increased 50%, making a 9-in. tie. Ties of 9-in. face spaced 20 ins. c. to c. will, with irregularities of spacing and widths of tie, give an average clear space of 10 ins., which is as small as is consistent with good tamping.

To give the required bearing of the tie on the ballast, use 9-in. ties spaced 20 ins. If the load is distributed uniformly by the tie throughout its length, the bearing on the ballast is 3.13 tons per sq. ft. If the load is distributed uniformly for 20 ins. each way from the rail, the bearing is 3.8 tons per sq. ft. Neither of these exceeds the allowed unit stress of 4 tons, but irregularities would probably bring the maximum intensity up to that amount.


3' 3"
10' 6"
3' 3"
1' 6"
1' 0"
8' 6" Tie
1' 0"
Slope 1 to 1
Stone Ballast - 19 cu ft per foot of Track
Gravel Ballast - 19 cu ft per foot of Track
Subgrade
24' 0" Roadbed
Cross Section; Single Track.
7"x9"x8' 6" Ties spaced 20 to a 33' 0" Rail = 20" c to c
Rail about 7" high, 6" Base, Section Modulus = 10.0
Stone Ballast
Gravel Ballast
Subgrade
Longitudinal Section.

PROPOSED TRACK SUPERSTRUCTURE FOR 60,000 LB. AXLE LOADS.

BALLAST.—By Johnson's formula, before referred to, the required depth of stone ballast is 17.67 ins., say 18 ins. This is a very large amount of stone ballast, and economy will usually result if gravel is substituted for part of it. By the Johnson formulas, gravel has just half the distributing value of stone, and its cost under the track may be considered practically half that of stone, so that, if we use 12-ins. of stone ballast and make up the other 6 ins. with twice the depth of gravel, we have 24 ins. of ballast; the lower 12 ins. being gravel and the upper 12 ins. stone. All depths of ballast used in this paper are depths under the tie. Such a depth of ballast will require a roadbed with a width of 24 ft., for single track, at subgrade, as indicated on the cross-section herewith.

BEARING ON SUBGRADE.—The width of distribution of a single tie load is, by the Johnson formulas, 27 ins., and substantially uniform distribution over the subgrade is secured when the tie spacing is 75% of that width, or 20¼ ins., which agrees with the spacing adopted. The load (with impact) is one ton per linear inch of roadbed, and if distributed over 10 ft. width the average load per sq. ft. on subgrade is 1.2 tons. The maximum is 1.33 tons per sq. ft.

The design of track indicated by this study would, of course, cost much more to build than any existing track, but, if properly built on a settled and permanent subgrade, properly drained and protected from accumulation of mud and cinders, it is reasonable to expect that the cost of maintenance of the track superstructure proper would be reduced more than half. The decreased maintenance cost together with the increased security and smoothness of riding would justify the larger capital expenditure. The foregoing design takes into account future increase of loads and may be considered somewhat visionary, and the limitations of present rail sections force us to the study of how to build the best track for existing loads using present rail sections of 80, 90 or 100 lbs. per yd. The figures deduced in the previous study furnish a guide to the methods of strengthening needed to reduce the unit stresses to proper limits.

*Abstract of a paper in Bulletin 30 (October, 1900) of the American Railway Engineering and Maintenance of Way Association.

†Bridge Engineer, Cleveland, Cincinnati, Chicago & St. Louis Ry., Cleveland, Ohio.

*Bulletin No 76, American Railway Engineering and Maintenance of Way Association.

ments to roofs, etc. An automatic switch lock attracted some attention. By the use of a lever rod with outstanding contact bar an approaching train would automatically throw shut a facing switch which might have been left open by negligence or mistake. Various shields for the protection of workers at emery wheels and buffing machines were shown, as was also an emery wheel with steel plates clamped on each side to prevent flying pieces in case of explosion. There were two large exhibits of safety engine stops in actual operation whereby the machinery can be brought instantly to a stop by pushing any one of many buttons scattered around the works.

In the photographic exhibit there were numerous illustrations of the care which is being taken by many large companies to safeguard the health of their employees. Well-lighted and ventilated rooms, sanitary plumbing and lavatory arrangements, and in some foreign examples model residences for the workmen, all illustrated the efforts to improve conditions and save life. The four foreign museums mentioned, after which it is hoped to model the American Museum, all sent photographs of their buildings and equipment.

In addition to the exhibits, which were in charge of attendants who explained the workings of the devices, Dr. Wm. M. Tolman, the Director of the Museum, gave frequent lectures on the objects of the society and the purposes of the exposition.

CONVENTION OF BRICK AND TERRA COTTA ASSOCIATIONS.

The conventions of three important associations in brick and terra-cotta or clay-working industries were held at the Planters' Hotel, St. Louis, Mo., last week, the combined conventions occupying five days and having a total registration of about 500 members and visitors. The principal association was the National Brick Manufacturers' Association; the others were the National Paving Brick Manufacturers' Association and the American Ceramic Society, which are closely identified with the first and hold their meetings conjointly with it. The first and last of these discussed papers on both the commercial and technical sides of the industries, while the second (and youngest) confined its attention to commercial considerations. The technical side of the paving brick industry, however, was well represented by papers read before the other associations, and it was suggested that in future such papers might be considered by the paving brick association. The convention was one of the most successful and most largely attended of those which have been held by these associations.

(1). AMERICAN CERAMIC SOCIETY.

This Society deals with the technology of the clay, glass and cement industries, and held seven sessions on Feb. 4, 5 and 6. Only a few of the papers were of engineering interest, and under the rules of the Society no abstracts of these may be made in advance of the publication of the official Transactions. These papers included the following: (1) "Porcelain for electrical purposes," by W. A. S. Watts (Victor, N. Y.); (2) "A high temperature carbon resistance furnace," by Allan Coggeshall and A. V. Bleininger (Columbus, O.); (3) "Compression tests on bricks," H. A. Wheeler (St. Louis); (4) "The difficulties of salt glazing Utah sewer pipe," by A. F. Greaves-Walker (Salt Lake City); (5) "Surface pimpling on salt glazed sewer pipe," by A. J. Aubrey (St. Louis); (6) "The effect of lime on the manganese employed in making grey brick," by John B. Millar (Toronto, Canada). A paper on "A study of the absorption test of clay products," by W. H. Ries (Ithaca, N. Y.), reviewed the results of tests made for the Geological Survey of Wisconsin to determine the relation of porosity of bricks to their strength and their frost-resisting properties. There were also several papers on kilns and plants for the manufacture of terra cotta.

At the evening session on Feb. 5, Prof. H. F. Bain, Director of the Illinois Geological Survey, described the work of the Survey, more particularly in regard to the clay resources of the state. In the discussion one member spoke of his early experiences when all knowledge of clay working was held as trade secrets, and compared this with the present time when numerous universities, institutions and persons are devoting time and energy to the investigation of clay resources, the properties of clays, and methods of clay working. The results of these investigations are made as widely public as possible, and to them the clay industry is largely indebted for its development.

The following officers were elected: President, Stanley G. Burt, Cincinnati, O.; Vice-President, Ross C. Purdy, Champaign, Ill.; Secretary, Edward Orton, Jr., Columbus, O. It was voted as the sense of the meeting that the next meeting shall be held at Columbus, O.

(2). NATIONAL PAVING BRICK MANUFACTURERS' ASSOCIATION.

This association held four sessions on Feb. 5 and 6, the meetings being devoted mainly to trade and business discussions, especially in relation to methods of promoting the use of brick paving. In the report of the President and Corresponding Secretary, Mr. W. P. Blair (Terre Haute, Ind.), it was stated that the association has had a number of booklets prepared for distribution to municipal officers, engineers and others. These include the specifications and instructions which were published in our columns some months ago; also a pamphlet on "Brick-Paved Country Roads," and one by Prof. I. O. Baker on "The Construction and Care of Brick Paving." Several universities and colleges are using the above publications in their engineering classes. The report also showed that about 5,000,000 sq. yds. of brick paving were laid last year by the companies represented in the association. The election of officers resulted as follows: President, W. S. Purington, Galesburg, Ill.; Vice-President, J. M. Robb, Clinton, Ind.; Treasurer, C. M. Crook, Youngstown, O.; Secretary, W. P. Blair, Terre Haute, Ind.

(3). NATIONAL BRICK MANUFACTURERS' ASSOCIATION.

This association held four sessions on Feb. 6, 7 and 8. Two afternoons were devoted to visits to several of the numerous clay-working establishments of St. Louis, and the annual banquet was held in the evening of Feb. 7. At the first session on the afternoon of Feb. 6, the general business of the Society was transacted, after which its technical program was taken up.

TRADE SCHOOLS.—The first subject was an address illustrated by stereopticon slides, on "The Importance of Trade Schools," by Dr. S. C. Dickey (Indianapolis). The old apprenticeship system has disappeared; in many trades apprentices are almost barred by the unions, and in a great majority of cases a boy who does succeed in entering a trade must learn it as best he can by blundering along and picking up what knowledge becomes available. On the other hand, there is a pressing demand in many trades for skilled workmen and foremen, and it is a problem for employers how to meet this demand. The address then dealt with the Winona Technical Institute, at Winona, Ind., where a number of trades and occupations are taught, and the success of which has been beyond expectation. Some trade organizations have provided funds for special departments and for scholarships. The address was followed by a description of one of the two trade schools at Philadelphia. Mr. J. M. Blair (Cincinnati) spoke very forcibly as to the need for education of this kind, and showed that many workmen to-day, having but a bare knowledge of their trade, take little interest in their work, with the result that it is difficult to obtain work of a high class.

At a later session, there was a topical discussion of the subject "What is the best means of increasing the number of journeymen bricklayers," in the course of which attention was called to the great need of manual training and trade schools, on as wide a scale as professional training in colleges and universities.

In the evening, Prof. Edward Orton, of Ohio State University (Columbus, O.), gave a lecture on "The Occurrence and Preparation of High Grade Clays for the Market," dealing with the white or kaolin clays of North Carolina and Florida. The clay is usually excavated in open pits and ground with water to a thin mud or "slip," the clay then settling in troughs or tanks. This was followed by an address on "Brick in Architecture," by Dean J. M. [illegible] of the University of Illinois, which was illustrated by a large number of lantern slides of ancient and modern brick structures in Europe, modern brick structures in this country, and architectural details executed in brick work. A paper presented at another session by Mr. [illegible] Schneider (Cleveland, O.) on "Life in Brick work" also dealt with the same question, and it was voted that these should be printed in pamphlet form for general distribution.

At the morning session on Feb. 7 the first paper was on "The Needs of the Hour," by Mr. C. B. Platt (Van Meter, Ia.). The principal need referred to was economy in cost of production, and particular attention was given to the advantages of producer gas for fuel. While the use of exhaust steam for drying is sometimes considered as an advantage in connection with the use of steam power, it is really of very little value, and is certainly not economical. In the discussion, one member stated that the brick industry, as a whole, is behind the times, the cost of production being about the same as it was ten years ago. This is due to the great waste of fuel, the waste in labor and the large proportion of bad product. Producer gas is being used in many lines of manufacture and should be much more generally used in clay working. Even if it effected no actual economy in fuel (and it should effect it) it would be of advantage in enabling the heat to be regulated better and in reducing the amount of labor. During the visits to various works in the afternoon, the necessity for radical improvements in the interests of economy and good work were very apparent.

BRICK VERSUS CONCRETE.—Lieut. J. A. Howard, U. S. A., then presented a paper on "The Strength of Brick and Brick Piers," giving the results of tests on brick, brick columns, etc., at the Watertown Arsenal. This led to some discussion as to concrete, and Mr. Howard supplemented his paper by particulars and diagrams of the results of tests on concrete and reinforced concrete. Several members spoke of the rapid development of reinforced concrete in both architectural and purely structural work, and made it evident that the brick manufacturer is finding in this material a serious competitor. On the other hand, Mr. T. A. Randall (Indianapolis) expressed the opinion that concrete construction when properly and honestly made is not cheap. Mr. Guignard (Columbia, S. C.) referred to the ill-effects of the campaign of concrete-block machine agents in persuading people as to the cheapness of their products. In one case, an agent erected a test building to show the fireproof properties of his blocks, but the structure fell and the blocks crumbled to pieces. In another case, a shop building of concrete blocks was so damp and wet that mechanics refused to work in it, and after it was lined with brick the extensions of the shop were built entirely of brick.

As a result of the papers and discussions on brick in architecture and in relation to concrete, it was voted that the association should take steps to open a campaign for the purpose of informing brick makers, architects, builders, property owners and others, as to the possibilities and advantages of brick in construction. This was one of the most important actions of the convention.

At the morning session on Feb. 8, a paper on "Mechanical and Hand Work in the Brick Yard" was read by Mr. W. P. Alsip (Winnipeg, Canada). Mr. A. R. Harwood (San Antonio, Tex.) then read a very short paper on "The Use of Heat from Cooling Kilns for Drying Brick," in which he expressed his satisfactory experience

with the Rogers system. This utilization of was used at the plant of the Western Brick Co., Danville, Ill., has been described in Engineering News. In the discussion, Mr. Cope, Birmingham, Ala.) stated that he is about to build a new plant in which the drying tunnel will be heated by gases taken from the boiler stack and the cooling kilns by two 12-ft. fans 6 ft. wide.

USE OF PRODUCER GAS.—This important subject was briefly presented by Mr. C. A. Leonard (Columbia, S. C.), who is a pioneer in this line, in a paper on "Burning Brick with Producer Gas." He has two continuous kilns of the Hoffman type, the first being on the common plan and the second on the tunnel plan. The former uses a little more coal but gives closer regulation of the heat and gives a little better product. There is a great saving in fuel and labor, and the product contains less broken and second-class brick. The fuel is run-of-mine coal, costing $1.70 per ton. One member referred to a plant where one man stokes three producers one an hour, and contrasted this with the amount of labor required for ordinary working. Another member reported unfavorable results where a central producer plant was used for burning individual kilns, to which it was connected by flues. It was shown, however, that in this case the air supply has to be raised from atmospheric temperature to kiln temperature (about 2,000° F.), while in the continuous kiln the air is previously heated. Plants of this kind can be successfully operated, but the amount of coal required will be about the same as with open fires; there will, however, be an economy due to centralizing the combustion of the coal in the producer. It was pointed out that a draft gage is a most important instrument in enabling a kiln to be properly regulated, although as a rule it is not used, but reliance is placed on the judgment of a "practical man" who opens and closes dampers as his experience dictates.

Mr. Edward Orton, Jr., Chairman of the Committee on Technical Investigation, briefly outlined the work which is being done with funds provided by the association, and stated that investigations are now to be made of apparatus and methods for drying brick.

PAVING BRICK.—Two papers on the subject were presented before the American Ceramic Society; one by Mr. Leonard E. Conlee (Columbus, O.) on "The Influence of the Rate of Cooling on the Toughness of Paving Brick," and the other by Prof. R. C. Purdy and Mr. Joseph K. Moore (University of Illinois) on "Pyro-Chemical Changes Occurring in the Burning of Clay Wares." In the discussion on the latter, Prof. Purdy stated that a good indication of the strength and value of a paving brick is given by a comparison of the specific gravity of the burned brick with that of the green brick (before burning). In a paper before the National Brick Manufacturers' Association, Prof. Purdy dealt with the methods of burning, and discussed the relation of density to strength of brick. He advocated slow burning to give hard and tough bricks, but Mr. W. P. Blair (Terre Haute, Ind.) did not think this could be accepted as a general proposition. It would depend very largely upon the clay. A paper on "Permanent Improvement of Public Highways," Mr. E. L. Powers (New York), was read by the Secretary; this reviewed the development and status of the State-aid system of improvement and suggested that brick paving might in many cases be used to advantage. In a written discussion Mr. H. S. Grimes (Portsmouth, O.) referred to its use on five miles of road, and considered it specially adapted to roads connecting villages with towns or cities and having a large traffic.

OFFICERS.—The election of officers resulted as follows: President, Wm. Conway, Philadelphia, Pa. Vice-Presidents, M. E. Gregory, Corning, N. Y.; Lemon Parker, St. Louis, Mo., and W. P. Blair, Terre Haute, Ind. Treasurer, J. W. Sibley, Birmingham, Ala. Secretary, T. A. Randall, Indianapolis, Ind. The next meeting of the three associations will be held at Columbus, O., in February, 1908.

COMPARATIVE COST of contract work and navy yard work on the battleships "Connecticut" and "Louisiana" has been computed by the Navy Department. The former was built at the New York navy yard; the latter by the Newport News Shipbuilding Co. The summary of cost of the two vessels is as follows:

	Connecticut.	Louisiana.
Cost of labor and materials applied to construction of hull and machinery:		
Under Bureau of Construction and Repair	$2,888,228	
Under Bu. of Steam Engineering	1,078,160	
Under Bu. of Equipment	202,920	$4,170,258
Amount paid to contractor for hull and machinery		$3,972,697
Cost of general superintendence, office expenses, etc., at Navy Yard, N. Y.:		
Under Bureau of C. & R.	58,256	
Under Bureau of S. E.	23,600	
Under Bureau of Equipment	1,222	
Cost of dealing and clerical work:		
C. & R.	108,527	58,245
S. E.	10,350	11,897
Equipment	11,622	805
Cost of inspection at works of sub-contractors for materials:		
C. & R.	1,062	1,332
S. E.	1,198	1,356
Approximate amount due contractors in final settlement		220,000
Total cost of hull and machinery (except armor and armament)	$4,326,193	$4,344,312
Cost of armor	1,562,668	1,679,250
Cost of turret mounts	242,986	256,310
Total cost of hull and machinery and including armor and such armament as is chargeable to "Title A, Cost of Construction" (Turret Mounts)	$6,131,848	$6,279,872

The difference in cost between the armor of the two ships is stated by the Bureau of Ordnance to be due to the fact that the armor of the "Louisiana" weighed 16.25 tons more than that of the "Connecticut." The difference in cost of the turret mounts is accounted for by the Bureau of Ordnance and stated to be "owing to the changes, alterations, experiments, and necessary slowness of manufacture as compared with material and designs which have already been manufactured and thoroughly tested out." The excess of $13,632 is not considered great.

Altogether the excess in cost of the "Connecticut" is surprisingly small, considering the fact that she was built at the New York Navy Yard, where living expenses and consequently wages are very much higher than at Newport News.

PANAMA CANAL EXCAVATION from the Culebra cut was 508,750 cu. yds. in January. This is the highest monthly record yet reached, October last being next with 325,825 yds. Heavy rains in November and December held the output below that in October. The arrival of large numbers of Spanish and Italian workmen is said to have put the labor question in very satisfactory shape.

THREE BRIDGES BETWEEN NEW YORK CITY AND New Jersey are recommended by the Interstate Bridge Commission which was appointed by the States of New York and New Jersey to investigate the inter-city traffic problem. One of the bridges, the Commission reports, should be across the Hudson somewhere between 59th and 72d Streets in Manhattan and would have an approximate span of 2,800 ft. The other two should span the kills which flow between Staten Island and New Jersey. The cost of the construction of the Manhattan bridge proper and the anchorages would not be less than $25,000,000 and might easily run to $35,000,000, while the two others should not cost over $500,000 each.

THE PROPOSED REFUSE DESTRUCTOR CONTRACT for the Borough of Richmond, New York City, is to be awarded to Beeman & Proudt, of Manchester, England, and 111 Broadway, New York City. The contract price is $23,805. The general specifications for the destructor were published in Engineering News of Dec. 6, 1906. Mr. J. F. Fetherston, Assoc. M. Am. Soc. C. E., is Superintendent of Street Cleaning of the Borough of Richmond; Mr. Louis L. Tribus, M. Am. Soc. C. E., is Commissioner of Public Works, and Mr. George Cromwell is Borough President.

THE FLOOD ON THE LOWER MISSISSIPPI, anticipated as a result of the floods in its upper waters and in the Ohio, reached its height at Memphis about Feb. 3. The gage readings were very close to the maximum flood record, but except in a few minor instances the levees all held and no very great damage was caused.

THE BREAK IN THE COLORADO RIVER had been so far closed on Feb. 9 as to give a head of 11.2 ft. against the closure works, and to allow only some 2,500 sec.-ft. to pass over the embankment, out of a total river flow of 20,500 sec.-ft. The discharge of the Colorado River at Yuma, Ariz., a few miles above the break, fell from 31,300 sec.-ft. on Feb. 3 to 17,000 on Feb. 7, rising to 20,500 sec.-ft. by Feb. 9. From Jan. 25 to 28 the level of the Salton Sea rose from Elev. 76.50 to 77.30. It remained stationary on Jan. 29, rose to 77.35 on Jan. 30, and remained at that point on Jan. 31—but the readings are apparently taken to the nearest 0.05 ft.

THE SINKING of the Joy Line steamer "Larchmont" off Watch Hill, Block Island, R. I., Feb. 11, resulted in great loss of life. The "Larchmont" was rammed by the schooner "Harry Knowlton" and sank almost immediately after the accident, which occurred about three miles off shore. The death list has not yet been completed, but it is stated that the "Larchmont" carried 150 to 200 persons, only nineteen of whom are known to have escaped death. Although many of the passengers left the wreck in the steamer's life-boats and rafts, the majority of these were frozen to death, the thermometer standing well below zero and a high sea running, so that they were soon incased in ice.

THE EXPLOSION of a Chesapeake & Ohio R. R. locomotive boiler near Winchester, Ky., killed three trainmen, Feb. 7. A heavy freight was being drawn by a double-header when the front locomotive exploded.

A BROKEN RAIL wrecked a limited train on the St. Louis & San Francisco R. R. near Birmingham, Ala., Feb. 8, and killed two men. All cars except the rear sleeper were ditched.

A GRADE CROSSING ACCIDENT occurred at Birmingham, Ala., Feb. 6, which resulted in the death of four persons. A freight train broke apart and the rear part crashed into the trailer of an electric car, overturning it.

SUBWAYS AND ELEVATED RAILWAYS as means of improved rapid transit are now being considered in St. Louis, Mo. Several public meetings have been held by associations of business men and the city authorities, but no definite scheme has been presented or adopted. The city proposes to build the subways, and to operate or lease them, and a bill has been introduced in the Missouri Legislature to give it the necessary power. Mr. Joseph Ramsey, Jr., formerly President of the Wabash Ry., favors a subway system in the down-town district with elevated extensions, as in Boston.

RAILWAY ACCIDENTS for the three months ending June 30, 1906, show total casualties to passengers and employees on duty of 11,850. The corresponding total for the preceding quarter was 16,937. The number of passengers and employees killed in train accidents was 265, as against 316 reported in the preceding three months—an increase of 73. The total number of collisions and derailments in the quarter was 1,672 (1,854 collisions and 1,788 derailments), of which 259 collisions and 201 derailments affected passenger trains. The damage to cars, engines, and roadway by these accidents amounted to $2,922,749.

COAL MINE ACCIDENTS in the anthracite and bituminous regions of Pennsylvania in 1906 caused the death of 1,623 persons, according to returns to the Department of Mines. There were 507 persons killed in the anthracite fields, 97 of these deaths being due to sleeve ground accidents. Of those killed underground 208 met death by falls of coal, 76 by mine cars, 77 by explosions and 45 by premature blasts. In the bituminous regions, 252 deaths were due to falls of coal, 87 to mine cars, 33 to explosions and 25 to electricity, while 23 deaths were caused by accidents outside the mines. Compared with the number of deaths due to mine accidents during the year 1905, these figures show a decrease of 102, the total number of deaths during 1905 being 1,725.

IRON AND STEEL, RAW AND MANUFACTURED, exported from the United States in the calendar year 1906 aggregated $172,500,000 in value against $140,000,000 in 1905, $128,500,000 in 1904, and $90,000,000 in 1903.

Exact details as to the distribution of these exports for the calendar year are not yet available, but accurate measurements of the exports of the fiscal year 1906 have just been completed by the Bureau of Statistics. They show that of the iron and steel exports in the fiscal year 1906, which amounted to $161,000,000, $72,000,000 worth, or about 46% of the total, went to the various countries of North America; $46,000,000 worth, or 27%, to Europe; while about $20,000,000 worth went to South America, $12,000,000 to Asia, $3,000,000 to Oceania (chiefly Australia) and about $4,000,000 to Africa. There was also a marked increase in importations of certain classes of iron and steel, especially those classes required for use in manufacturing. Pig iron was imported during the year to the value of practically $12,000,000, against $7,000,000 in 1905 and less than $2,000,000 in 1904; and this large importation in 1906 was made in face of the fact that the home production of pig iron was far in excess of any earlier year and of any other country, the home production being, according to the best estimates, 25,700,000 tons, against 22,000,000 in the preceding year.

and exceeding in quantity the combined production of the United Kingdom and Germany, the two next greatest world producers of pig iron.

THE HUDSON RIVER TUNNELS described in our issue of Jan. 3, 1907, have progressed in very good shape during the year 1906, according to the annual report of Chief Engineer C. M. Jacobs. 12,160 ft. of tube tunnels were driven in the four lines of work, and 4,357 ft. of concrete-lined tubes in the work under the terminals on both sides of the river. The North and South Tunnels (the old Hudson River Tunnels) are completed as far as the driving is concerned, and are being cleared preparatory to laying track. The tunnel under Sixth Ave. has just been started.

The stations at Jersey City and Hoboken are well under way, but the New York terminal, over which the immense Terminal Buildings will be built, has only progressed as far as the caisson work. This will probably be the last of the work to be completed. The following quantities give some idea of the amount of work done during the year: 31,350 cu. yds. of excavation, 37,534 tons of iron or steel in place, and 52,100 cu. yds. of concrete in place.

REVISION OF THE BUILDING CODE of New York City has been before the local Board of Aldermen for some time. Last year the Building Committee of the Board recommended the appointment of a commission to advise as to changes, but such criticism of the proposed commission's make-up was aroused that the recommendation was withdrawn. Recently the Committee again considered the subject, and as a result appointed an expert commission of ten, made up as follows: Charles H. Israels (architect), Electus D. Litchfield (architect, Rudolph P. Miller (consulting engineer), Charles O. Brown (consulting engineer), Charles G. Smith (engineer, representing Fire Underwriters), George Vassar, Jr. (builder), Theodore Starrett (builder), Thomas E. Cosgrove (stone mason), George Harsch (bricklayer) and William Blau (counsel). This commission has already had its initial meeting, electing Mr. Israels chairman.

A CITY PLAN FOR COLUMBUS, OHIO, with the idea of developing and beautifying the city, is to be reported on by the Columbus Plan Commission. This body was recently appointed by the Board of Public Service and consists of the following five members: Austin W. Lord, of Lord & Hewlett, Architects, of New York, who has been elected Chairman of the Commission; Charles Mulford Robinson, of Rochester, who has been elected Secretary; Albert Kelsey, of Philadelphia; Charles M. Lowrie, of New York, Landscape Architect, and H. A. MacNeil, of New York, Sculptor. The City Council has appropriated $5,000 for the work of the Commission. The first meeting of the Commission was held during the last week in January.

PERSONALS.

Mr. Michael S. Niland has resigned as Superintendent of Division No. 10 of the Erie Canal.

Mr. David R. Lyman has been promoted to First Assistant City Engineer of Louisville, Ky.

Mr. Frank McLennan, of Cornwall, Ont., has been made Manager of the Cerro de Pasco Mining Co.

Mr. Roswell L. Gardner, Superintendent of Water-Works at Springfield, Mass., has been elected City Engineer.

Mr. H. H. Harman, Acting Engineer of Bridges for the Bessemer & Lake Erie R. R., has been made Engineer of Bridges.

Mr. F. W. Brooks, Assistant General Manager of the Detroit United Ry., has been promoted to General Manager.

Mr. J. C. Murray, Chemist for the Londonderry Iron Co., has resigned to accept the editorial management of the 'Canadian Mining Journal."

Mr. R. G. Long has been appointed Master Mechanic of the Missouri Pacific Ry. at Fort Scott, Kan., to succeed Mr. W. C. Walsh, resigned.

Mr. G. F. Carr, recently of the O. & F. Braniff & Co., Maconi, Mexico, has become Mining Engineer for the Arizona Commercial Copper Co., Globe, Ariz.

Mr. J. Parker has resigned as Manager of the Brown-Alaska Co., Prince of Wales Island, Alaska. He will open an office at Seattle, Wash., as a consulting mining engineer.

Mr. W. T. Oviatt, of the Connecticut Railway & Lighting Co., has been promoted to be General Manager of the gas, electric and water plants of this company, with headquarters at Waterbury, Conn.

Mr. Joseph Ripley, Principal Assistant Engineer on the Panama Canal has been promoted to Assistant Chief Engineer, to succeed Mr. J. G. Sullivan, resigned. Mr. F. B. Maltby, Division Engineer, succeeds Mr. Ripley as Principal Assistant Engineer.

Col. E. E. Farnsworth, General Manager of the Great Northern Portland Cement Co., of Marlborough, Mich., has resigned. He is succeeded by Mr. W. S. Pritchard, formerly of the Lehigh Valley Cement Co. Mr. James C. Kennedy becomes Assistant Manager.

Mr. Henry Rohwer, M. Am. Soc. C. E., Consulting Engineer, St. Louis, and Mr. Carl Gayler, M. Am. Soc. C. E., Engineer of Bridges and Viaducts of the city of St. Louis, have been appointed Consulting Engineers to the committee which is considering sites of the proposed new bridge over the Mississippi River.

The item in this column in our issue of Feb. 7 relative to changes in the engineering heads of the Metropolitan Water and Sewerage Board of Massachusetts contained some errors. A correct statement of the changes is as follows: Mr. Frederic P. Stearns has recently resigned as Chief Engineer and been made Consulting Engineer of the Board, and Mr. Dexter Brackett, formerly Engineer of the Distribution and Sudbury Departments, has been appointed Chief Engineer of Water-Works, and Mr. William M. Brown, formerly Engineer of Sewerage Works, has been appointed Chief Engineer of Sewerage Works.

Mr. O. H. Ensign, of the U. S. Reclamation Service, has been made Chief Electrical Engineer in charge of electrical and mechanical matters. His office is at 321 Merchants Trust Building, Los Angeles, Cal. Mr. Ensign was appointed Electrical Expert of the U. S. Reclamation Service on Nov. 1, 1904, and for eight years previous to that time had been Electrical and Mechanical Engineer to the companies now known as the Edison Co. of Los Angeles. Prior to that time he had been connected with several California companies, The General Electric Co., Schenectady, N. Y., the Edison Co., New York City, the Schenectady Locomotive Works and the Ithaca Machine Shops.

Obituary.

Carlo Gutherz, a well-known architect of Washington, D. C., died at his home in that city Feb. 7, aged 62.

Henry C. Whiting, formerly General Manager of the California Northwestern Ry., died Feb. 1 at San Francisco, Cal., aged 73 years.

Charles Harding Loring, Engineer-in-Chief (retired) of the U. S. Navy, M. Am. Soc. M. E., died at Hacketts-town, N. Y., Feb. 5, of paralysis. He was born at Boston, Mass., Dec. 26, 1828, and entered the navy Feb. 26, 1851, as Engineer Officer. During the Civil War he served with the North Atlantic Squadron. He was appointed Engineer-in-Chief of the navy in 1884, and was retired on account of age in 1890 with rank of Captain. Captain Loring was Vice-President of the American Society of Mechanical Engineers during the years 1883-1885, and President during 1891-1892. He was also a member of the Society of Naval Architects and Marine Engineers.

Alfred Walter, President of the Seaboard Air Line Ry., died at his home in New York City, Feb. 12, of kidney trouble. He was born at Brooklyn, N. Y., Oct. 2, 1851, and was graduated from the Rensselaer Polytechnic Institute at Troy, N. Y., in 1872. He entered the employ of the Allegheny Valley Ry. as a rodman on July 12, 1872. In 1874 he became Assistant Supervisor of the Pennsylvania R. R., later becoming Supervisor of the Northern Central Ry. On May 1, 1878, he was appointed Assistant Engineer of the Motive Power Department of the Pennsylvania R. R. From 1882 to 1889 he was Superintendent of the Sunbury Division of the Pennsylvania R. R. and the Shamokin Division of the Northern Central Ry., when he was appointed General Superintendent of the Baltimore & Ohio R. R., in charge of its operations east of the Ohio River. On March 1, 1892, Mr. Walter became General Manager of the Erie R. R. and retained this position until 1894, when he was elected President of the Delaware, Susquehanna & Schuylkill R. R. He was elected President of the Lehigh Valley R. R. in 1897, but retired in 1902. After several years' rest Mr. Walter took charge of coal development projects in southwestern Virginia for the Blair-Ryan-Ream interests, and on May 1, 1906, was elected President of the Seaboard Air Line Ry. He was also President of the Baltimore Steam Packet Co., and the Macon, Dublin & Savannah R. R.

ENGINEERING SOCIETIES.

COMING MEETINGS.

NEW ENGLAND GAS ASSOCIATION.
Feb. 21. Annual Meeting at Boston, Mass. Secy., N. W. Gifford, East Boston, Mass.

ASSOCIATION OF ONTARIO LAND SURVEYORS.
Feb. 26. Annual Meeting at Toronto. Secy., Killaly Gamble, 405 Temple Bldg., Toronto, Ont.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 19-21. Annual Meeting at Chicago, Ill. Secy., L. C. Fritch, 1502 Monadnock Block, Chicago, Ill.

IOWA ELECTRICAL ASSOCIATION.
April 18-19. Annual Meeting at Clinton, Iowa. Secy., L. B. Spinney, Iowa State College, Ames, Iowa.

THE AMERICAN RAILWAY ASSOCIATION.
April 24. Annual Meeting at Chicago. Secy., W. F. Allen, 24 Park Pl., New York City.

AMERICAN SOCIETY OF CIVIL ENGINEERS.—The society held its regular business meeting at its house on Feb. 6th, Mr. V. H. Hewes in the chair. A paper by Capt. Spencer Cosby on "Lighthouse Construction in the Philippines," was read by the secretary, and followed by a written discussion by Col. C. E. L. B. Davis. It was announced that the next regular summer convention of the society will be held in the City of Mexico some time between June 20 and July 20. The society is going as a guest of the Mexican Government which will furnish free or at a nominal cost all transportation within its boundaries.

MONTANA SOCIETY OF ENGINEERS.—The twenty-second annual meeting was held at Butte, Mont., Jan. 10-12. Thursday morning the delegates took a trip to Anaconda, Mont., where they inspected the Washoe Reduction Works. Friday the Montana State School of Mines at Butte was visited, and a trip through the "Leonard" mine enjoyed. The officers elected for the ensuing year are President, Mr. E. C. Kinney; First Vice-President, Mr. Archer E. Wheeler; Second Vice-President, Mr. Arthur H. Wethey; Secretary and Librarian, Mr. Clinton H. Moore; Treasurer and Member of the Board of Managers of the Association of Engineering Societies, Mr. Samuel Barker, Jr.; Trustee, Mr. Azelle E. Hobart. Prof. Geo. W. Craven, of the Montana State School of Mines, read a paper on "Concrete and its Practical Uses," and Prof. A. N. Winchell described some experiments in the "Genesis of Copper Ores." The convention closed with a banquet Saturday evening.

GENERAL SOCIETY OF MECHANICS AND TRADESMEN.—At the regular meeting held at the society house, 18 West 44th St., New York City, on the evening of Feb. 6, an illustrated address on "Reinforced Concrete" was delivered by Mr. Rudolph P. Miller, Consulting Engineer. After some introductory statements designed to explain the general nature of reinforced concrete as a definite new material, the speaker showed views of many special forms of reinforcing metal, and drawings and photographs of reinforced-concrete buildings. He then mentioned and explained some of the practical factors bearing on successful construction in this material, for example, the importance of getting the reinforcement in precisely the position shown in the design, and the necessity of securing a uniform thorough mixture of concrete, placed continuously and uniformly. Two of Mr. Miller's recommendations are worth noting particularly: (1) He strongly urged that a consulting engineer—not a contractor who also provides the engineering work for his job—be employed, and indeed that no reinforced-concrete work should be attempted without the advice and constant guidance of an engineer; (2) he voiced the opinion that the unit-stresses hitherto used have generally been too high; that is, the factor of safety too low, and that the future would see the general adoption of lower unit-stresses. The relation of reinforced concrete to fire protection was also touched upon. In this connection some fire tests made by the National Fireproofing Co. on concrete columns with and without tile protection were cited, as tending to show that current types of reinforced-concrete building construction are not ideal in their resistance to hot fire.

ST. LOUIS RAILWAY CLUB.—At the meeting held at the Southern Hotel on Feb. 8, Mr. John P. Moore read a paper on "Some Experiences and Suggestions," relating to the rules for and the conduct of employees in the various departments of railway service. Mr. Geo. J. Tansey, President of the St. Louis Transfer Co., then read a paper on "The Terminal Question from the Viewpoint of a Transfer Man." He briefly reviewed the complicated problem of railway terminals and the handling of freight in St. Louis, and the different schemes of improvement which have been suggested, and then presented his own ideas on the subject. He considered that the railways coming in from the West should maintain their present general arrangement of terminals (but improved in detail) and that those coming in from the East should establish extensive terminals across the river at East St. Louis. The handling of through cars would be effected by the present Terminal Railroad Association. Local freight would be handled between the freight sheds and the city warehouses by teams operated by the railways, as is done in England. The subject was discussed, by invitation, by Mr. E. E. R. Tratman, Associate Editor of Engineering News, who outlined the principles underlying the design of railway terminals and the difficulties which attend the proper application of these principles under the conditions of any given locality. He also described the purpose of the great clearing yard at Chicago, which was intended for the joint use of all the railways; it was built some years ago, but the railways have declined to make use of it and it has never yet been put in actual service.

At the March meeting Mr. C. C. Schwartz, of the St. Louis Refrigerator Car Co., will discuss the question of increase in cost of maintenance of cars due to the rough handling incidental to the use of heavy trains and more powerful engines, and particularly to switching. In the private car equipment of this company the cost of maintenance in 1906 was 60% higher than in 1905.

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. New York, February 14, 1907.

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EDITORIAL.

A prefatory note in one of the books reviewed in this issue makes a half apology for the fact that "the cheaper process of photo-lithography" was used, instead of lithography, in preparing the illustrations. The surprising thing about this is the fact that any apology should be thought necessary for means of reducing the price of a technical book. In this country [the work in question is foreign] we are so used to high, even appallingly high, prices of engineering books that such an apology would be quite impossible. The day must come when technical books will be cheaper, although it seems a long way off. The fault, we feel competent to add, is not all the publisher's. A large part is due to the author, who presents for publication manuscript and illustrations that require months of labor before they are ready for the mechanical processes of book production. And another part comes upon the book-buyer; rather the non-buyer. Engineering books sell in very small editions. It is exceptional when more than two or three thousand copies of one work are sold. When the acquisition of a good technical library comes to be a more important matter to each individual engineer, and also when we reach the golden age where the student will learn his science and practice from the hand-books of the practicing engineer and text-books of engineering become a thing of the past, then our books of engineering can be sold at prices which now are impossible to the publisher.

CORRESPONDENCE.

Slocum and Hancock's Strength of Materials: The Review Reviewed.

Sir: In the Supplement of Dec. 13, 1906, the above work was reviewed by Prof. L. J. Johnson. In this review great stress was laid upon certain minor features of the book, such as whether or not it is advisable to give a certain reference in a foot-note, and again whether the second derivative should be expressed as

$$\frac{d\left(\frac{dy}{dx}\right)}{dx} \quad \text{or simply} \quad \frac{d^2y}{dx^2}$$

Such criticisms might well pass unnoticed if the reviewer had not dwelt upon them to the exclusion of any adequate or proper review of the book, using the space at his command for exploiting his own ideas on how a book should be written.

Prof. Johnson criticises the statement of Euler's formula in the form

$$EI\frac{d^2y}{dx^2} + Py = 0$$

as a "blind adherence to scholastic conventionalities," stating that it should have been written

$$EI\frac{d\left(\frac{dy}{dx}\right)}{dx} + Py = 0.$$

Why the authors should not be permitted the use of the neat and convenient notation universally used for the second derivative it is hard to see. The reviewer further criticises the authors for saying that in order to integrate this equation it should be multiplied by $2\frac{dy}{dx}$, and then giving a reference in a foot-note to the calculus forming part of the same series of texts. In explanation of the reference to the calculus it may be said that this was not included in the original manuscript, but was inserted at the request of the editor of the series. It seems rather far-fetched, therefore, to characterize it as "a kind of artificialism rampant in elementary text-books," and accuse the authors of an intentional "lapse into obscurity and mysticism."

The definition of the common theory of flexure is cited as "an illustration of unfortunate terminology." Whatever the reviewer's personal opinion may be as to what the theory of flexure should include, that stated in the text is the one in actual use, and is therefore entitled to be called the "common" theory.

The course outlined in the text is intended to supplement courses in calculus and theoretical mechanics. For this reason the general theorems on products and moments of inertia are entirely omitted, except for a brief statement of the five principal theorems on moments of inertia for convenience of reference. This, however, is made by the reviewer a pretext for criticism as a "most unfortunate and misleading omission, and not a legitimate bit of condensation."

These are the points on which the reviewer chiefly lays emphasis, passing over the really important features of the book in the brief statement that "the strong points of the book are numerous. The material is, on the whole, well chosen. A fine assortment of numerical problems is furnished," and "the treatment of hooks and other curved pieces is interesting and valuable." On these premises the reviewer concludes his article by a lament that "lucid, straightforward, truly scholarly and invigorating text-books" are not at present provided for engineering students, implying that the present work is lacking in all these elements. As a matter of fact, the book is based on years of study of the best modern and classic works of England, Germany, France and America, the aim of the authors having been to give a comprehensive modern presentation of the subject in a form easily intelligible to American students. In view of this fact, the authors believe that the reviewer's hasty generalization is peculiarly inapt and misleading.

In justice to themselves, therefore, the authors invite examination and candid criticism of their book, having entire confidence that the general verdict of the engineering profession will set right the injustice done them by the review in question.

Jan. 1, 1907.

S. E. Slocum,
University of Cincinnati, Cincinnati, Ohio.
E. L. Hancock,
Purdue University, Lafayette, Ind.

[The above letter was submitted to Professor Johnson, who in reply refers to the review itself. We suggest that readers interested in the subject of Strength of Materials should read the original review and the above letter in juxtaposition. Such comparison must suffice to define the points at issue. One point, however, demands a further statement, which we undertake even at the risk of appearing partisan. "Common theory of flexure," as we know it, is a specific term used to denote that series of assumed conditions, or these conditions and the associated mathematical procedure (not a rigid one, but involving certain approximation) which yield the beam formula

$$S = \frac{M}{I/c}$$

or, if Prof. Johnson prefers it that way,

$$S = \frac{N}{A} \pm \frac{M}{I/c}$$

All assumptions and approximations which this derivation requires, as against a rigid analytical theory, are required to make up the "Common theory." They include

(1) The assumption that Hooke's law is true,
(2) The assumption that plane sections remain plane,
(3) The neglect of vertical shear deformation,
(4) The assumption that dl is equal to dx,
(5) The assumption that the compressive modulus is equal to the tensile modulus of elasticity,
(6) The neglect of conjugate effect from the transverse compression,

(none of which appears to have been mentioned by Messrs. Slocum and Hancock), and possibly one or two other assumptions. Now, it is of the utmost importance that a student of the subject should acquire a definite and precise idea of the meaning of "Common theory of flexure." We have several times, recently, observed that not all courses in Strength of Materials insist on this; the above letter alone evidences this.—Ed.]

On the Review of Railroad Location Surveys and Estimates.

Sir: In Mr. M. P. Paret's review of my book on "Railroad Location Surveys and Estimates" there are several statements which hardly agree with the facts, and which I should be glad if you would give me the opportunity to correct.

The reviewer quotes the author as stating that "one of the objects of a location survey, where a tentative rate of grade has already been established, is to determine what the lowest practical ruling grade will be," and then goes on to say: "The reviewer holds that it is the preliminary survey which develops this feature and not the location survey." The author quite agrees with what the reviewer evidently intends to convey as his opinion, but a distinction should be clearly made as between the expression "Location Survey," which is generally intended to cover the whole survey from the reconnaissance to the staking-out of the final line, and the "Final Location," which is the term generally applied to the staking-out of the line finally determined after all the considerations affecting it have been properly weighed and balanced. That the author did not intend that the determination of the rate of grade should be left until the final location, to take only two instances out of many, is indicated by the following statements (page 53) from the chapter on "The Preliminary Survey": "One of the first problems to be solved is, what the rate of grade shall be"; and again, "The general broad questions affecting the whole line must be definitely settled before any time is spent working out details."

As indicated by the last portion of the first paragraph of the review, and at various other places, the reviewer does not grasp the fact that the whole emphasis of the book is placed on the value of the projected location and its profile, which is advocated as a far better means of working out the preliminary problems than any other method based on a mere preliminary line alone or the profile of it, and that the staking-out of the final line on the ground is merely reproducing there, with some refinement as to details, what has previously been determined is the best line. The author has reason to believe that the reviewer uses this method on his own work, this being especially necessary and important in such country as is found on the western end of the Kansas City, Mexico & Orient Ry., between Guerrero and Topolobampo.

The reviewer states also that "among the results to be obtained by location surveys, nothing can be found [in the book] about economic maintenance or the development of a business giving maximum net revenue." In regard to the former, the author states on page 16: "Economy of operation [which, of course, involves maintenance] plays an important part" [in determining the location]; and further along: "Of two lines . . . the one which costs the least to build may not be the most economical because . . . it may cost so much more to operate it, etc."; also, still further on (page 16): "In order that the comparison of two lines may be complete . . . proper allowance must be made for . . . any additional cost of maintenance of one line over the other"; and again (Chap. VIII., p. 167): "Where the cost of maintenance of one line is liable to be much more than another, this, of course, must be given due consideration, as well as other factors of line and grade, which influence operating expenses." Referring to the latter part of the statement,

the author considers that the location of the line in reference to possible traffic "involves a discussion of the theory of railroad location beyond the purpose of the present work," and demands greater knowledge and much more extensive experience than is to be ordinarily expected from the man in charge of the work in the field in a position paying $175 to $200 per month.

It is also stated in the review that the marking of stakes to hundredths on preliminary lines is advocated by the author. This is clearly due to a hasty reading, as, under the sub-heading "Marking Stakes," the author states (p. 9): "There will seldom be plusses at anything but even feet on preliminary." The figure ("E," Fig. 2) showing the manner of marking a preliminary stake shows only even feet in distinction to the location stakes, which all show hundredths. The first two paragraphs on page 62 would also have shown that no such unnecessary refinements, even on location in ordinary undeveloped country, is advocated.

Again, the reviewer states that no mention is made of the need of obtaining information on the reconnaissance as to water supplies for the surveying parties who follow. The following quotation is from page 24: "The result of this first reconnaissance" was "to familiarize him (the locating engineer) with the . . . sources of supplies, camping places, and of water, etc."

In regard to breaking chain, there can be no possible question as to the advisability of always pulling the chain ahead its full length, whether for measuring a plus or when it is necessary to "break-chain," as nearly all the errors in chaining come from subtraction from the 100-ft. end. The difference in measuring around the arc of a 4° curve instead of along the chord for a full station is 0.03 ft., instead of 0.0057, as might be inferred from the review. The author has never heard the expression "to break-chain" used in any other sense than that applying to the measurement of a distance in two or more parts when the inequalities of the ground necessitate it, which the reviewer has evidently mixed up with measuring a plus. If a plus on a curve is to be located, the measurement is direct from the last even station (as the reviewer wishes to show), but the measurement between two even stations should be along the chord and not around the arc, as would be the case were lines given for each "break" in the measurement of the 100 ft.

The definition of "Sounding" given by the Century Dictionary is "the act or process of measuring the depth of anything; exploration, etc.," but while it is therefore permissible to use this term, which is that commonly used in the West, the author will agree with the reviewer that common practice might well be changed in this respect, so as to confine sounding to depth of water, and borings or test pits, as the case might be, to explorations under ground.

Yours very truly,

F. Lavis, M. Am. Soc. C. E.

42 South Tenth Ave., Mt. Vernon, N. Y., Jan. 24, 1907.

Purdue Tests of Locomotive Performance.

Reviewed by ARTHUR M. WAITT,* M. Am. Soc. M. E.; M. Am. Soc. C. E.; Assoc. Am. Inst. E. E.

LOCOMOTIVE PERFORMANCE.—The Results of a Series of Researches Conducted by the Engineering Laboratory of Purdue University. By William F. M. Goss, Director of the Engineering Laboratory and Dean of the Schools of Engineering, Purdue University. New York: John Wiley & Sons. Cloth; 6 × 9 ins.; pp. 439; 229 illustrations in the text. $5.

This valuable work by Dr. Goss covers the very important field of locomotive steam engineering from a standpoint that prior to the development of the Engineering Laboratory at Purdue University was never possible.

The data heretofore obtained relative to the various operations combining to produce "locomotive performance" have necessarily been studied under great disadvantage and subject to varying conditions of service, which have often thrown a cloud of unreliability over the results obtained. The establishing of Purdue Engineering Laboratory, equipped with a full-sized modern locomotive and provided with a corps of trained experts and assistants, has made it possible, during the past fourteen years, to eliminate to a very large extent undesirable variations in conditions and to arrive at conclusions in locomotive performance based on constant or uniform conditions.

Dr. Goss has combined in this volume the most important results obtained from the Purdue tests, records of which have from time to time been separately published, together with other material never before published, thereby making "a permanent and accessible record of the work of the laboratory."

The first four chapters are devoted to the general subject of Locomotive Testing. The history of the growth and development of the Purdue Engineering Laboratories and Locomotive Testing Plant is briefly referred to, together with a description of the first test locomotive ("Schenectady No. 1") and the housing built for its reception and the apparatus composing the plant for testing its operation. Details are given of the supporting axles and wheels, the Alden friction brakes and the traction dynamometer, both by text and illustrations. Some of the difficulties experienced in the first designs are referred to, as well as the fire in 1894, which made possible the construction of the second testing plant, in which the weak points discovered in the earlier one were corrected, and which was equipped more amply and completely than had been feasible with the first plant. The second plant is fully described and illustrated by drawings and photographs taken when it was in full operation.

In Chapter II. brief reference is made to the special feature of the Purdue Testing Plant, in that it permitted a locomotive to be tested under conditions and loading in a perfectly normal way. Chapter III. gives a detailed description and specification, supplemented by numerous detail drawings, of what was known as Locomotive "Schenectady No. 1." This is the locomotive from the operations of which the greater part of the data discussed in the book were obtained.

Several pages are devoted to a careful description of the details of the method of locomotive testing and the manner of obtaining and recording the data regarding fuel used, quality of steam pressure, as shown by indicator cards, and the summary of results. Twenty-five pages are given to the tabulated results and explanations of 44 efficiency tests made upon locomotive "Schenectady No. 1," which have been very carefully and completely worked out, showing "general conditions," "boiler performance," "engine performance," and "locomotive performance" as a whole.

Chapter V. is devoted to showing "by means of data derived from experiments the effect of changes in speed and cut-off upon the power and efficiency of a locomotive when running under a wide-open throttle." The discussion of this data is made especially valuable by the reference and deductions in connection with "wire drawing," "mean effective pressure," "indicated horsepower," "steam consumption," "critical speed," "cylinder condensation," etc. The chapter is abundantly supplied with diagrams and tables which make the subject more readily comprehended.

Seven chapters are given to the careful consideration of "The Boiler." First there is presented a general discussion of the "boiler performance" in the series of 44 efficiency tests. This is amplified by numerous tables of comparisons and illustrations from the recording charts, and closes with a number of "conclusions" deduced from a careful study of the results obtained.

An interesting chapter is devoted to consideration of the relation of "high rates of combustion and boiler efficiency." In this chapter are detailed interesting experiments with varying proportions of dead and effective grate surface. The various losses due to grate, sparks, poor combustion, etc., are referred to. The conclusions are illustrated by two diagrams, based on the tests, which show the evaporative efficiency and rate of combustion, and the losses in evaporative efficiency.

Chapter VII. gives an account of a series of tests made to note "the effect of thick firing on boiler performance." These tests gave results the reverse of what was expected and lead up to the conclusions which close the chapter.

A very interesting chapter is devoted to "spark losses," which were investigated with great thoroughness both as regards size, quantity, heating value, weight, etc., and which have enabled several new and interesting conclusions to be drawn.

Radiation losses have rarely been measured heretofore, hence the 24 pages devoted to description of a series of tests both when a locomotive was standing in a building, as well as when running on the road, are of manifest interest. These tests showed very clearly the great difference in value of various kinds of boiler coverings, and were productive of several interesting conclusions which close the chapter.

In the chapter on "The Front End," over 50 pages are devoted to a most interesting and valuable series of tests on this hitherto much abused but poorly understood feature of the locomotive boiler. In this, one of the most important chapters of the book, are described numerous investigations and experiments to determine the distribution of the draft in the apparatus intervening between the front end and the ash pan, and also an extensive study of the action of the exhaust jet. The tests for the study of this subject were made in cooperation with a committee of the American Railway Master Mechanics Association. The results of these most thoroughly and carefully conducted tests have given to railway mechanical engineers the first absolute data regarding the action of the exhaust under differing conditions, such as changes in speed, height of bridge in single exhaust pipes, influence of size and style of tips, etc. A most complete and searching set of tests to determine the relations between the stack, the nozzles and the draft are described, and diagrams, tables and conclusions are given which throw more light on this complicated problem than has ever before been made known. These tests have enabled data to be given and formulas for designing a front end, including stack, exhaust nozzle, and general relative dimensions of parts, that will produce a maximum of efficiency, as deduced from the widely varying styles and dimensions experimented with. Perhaps no more valuable contribution to technical knowledge of the action of the locomotive has been published for many years than that contained in this interesting chapter on "Front End."

The discussion on "The Boiler" concludes with

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a short chapter on "superheating in the smokebox."

The fourth section of the book (seven chapters) considers "The Engines." In Chapter XIII. is found a presentation of "indicator work," in which the author describes the application of the indicator to "Schenectady No. 1," and gives a discussion of the features affecting the results obtained by indicators. The conclusions at close of chapter on this subject will be helpful to all who desire to draw the most reliable deductions from indicator work. This is followed by conclusions based on special studies as to "the effect of load" upon locomotive performance, which presentation is amplified by numerous diagrams, tables and samples of indicator cards. The "effect of outside lap" upon locomotive performance is discussed and illustrated in a similar manner, followed by an equally clear study of "the effect of inside clearance."

"Locomotive valve gears" are analyzed in a special chapter, which describes the function of a valve gear, the results accomplished with the Stephenson gear, and a description of the objects sought and methods used in various improved valve gears.

In a chapter on "action of the counterbalance," some ingenious and effective experiments to determine the exact action of varying methods of counterbalancing are described and illustrated, and the results are briefly summed up in several valuable conclusions which close the chapter.

The discussion of "The Engine" concludes with a chapter on "machine friction," in which the author describes the methods used to determine the value of this factor of loss in engine performance, and gives his conclusions as to the main features in operation which effect "machine friction."

The concluding portion of the work is devoted to "Locomotive Performance" as a whole, in which numerous important items effecting the results obtained from a locomotive are very clearly presented. "The effect of throttling" is made clear by a series of special tests, the results of which are carefully tabulated, so that one may arrive at definite conclusions as to whether the engine should be run under the throttle or by the reverse lever. The "effect of high steam pressures on locomotive performance" is presented in its various phases, and the arguments, pro and con, are stated. The chapter has an addenda, in which the results of a most elaborate series of tests made at Purdue in 1906 are given. The conclusions based on these tests are among the most valuable, from a practical point of view, of any in the book.

A valuable addition to scientific data wanted by the student of locomotive engineering is made in the 34 pages devoted to "atmospheric resistance to the motion of railway trains." In this chapter the author describes in detail a series of novel and well-devised original experiments to determine this hitherto very uncertain data. The results obtained were so well verified and duplicated as to permit the deduction of valuable and reliable conclusions as to wind resistance to moving locomotives and cars which appear in the shape of simple formulas for arriving at the results wished for the various units composing any train. The diagrams and tables in this chapter are very convenient for facilitating calculations.

The concluding chapter in the book is "a generalization concerning locomotive performance" in which an application is made of the various deductions of the preceding chapters, enabling one "to make estimates concerning the performance of locomotives in general and to construct equations expressing performance with reference to several important functions." These applications are illustrated by applications to several typical locomotives selected from prominent railroads.

An index at the end of the book makes reference to any paragraph quite simple owing to its unusual completeness.

This work of Dr. Goss' will rank at the head of the scientific and technical standards of reference in locomotive engineering. It presents information on important points obtained with great care and accuracy and under conditions never before made possible until the establishing of the Purdue Testing Plant and Engineering Laboratories.

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Drawing for Mathematicians.

Reviewed by VIRGIL SNYDER.*

MATHEMATICAL DRAWING.—By G. M. Minchin, M. A., F. R. S., Professor of Applied Mathematics at the Royal Indian Engineering College, Cooper's Hill, and J. B. Dale, M. A., Assistant Professor of Mathematics at King's College, London. London, England: Edward Arnold. New York: Longmans, Green & Co. Cloth; 5½ x 8¾ ins.; pp. 145; 102 figures in the text. $2.10, net.

This book is of rather more interest to the mathematician than the engineer; it has several features that are of value to both, but is too brief to be of greatest service to either. It presupposes a knowledge of analytic geometry and the calculus, so far as methods are concerned, but makes no use of theorems proved by them. It begins with a very elementary treatment of rectangles, squares, approximations for π and the length of circular arc, then gives a detailed explanation of Amsler's planimeter, with its application to the determination of center of gravity and moment of inertia. A liberal number of exercises for the student are added to each section. Chapter II., on the construction of conics by metrical methods, is roughly co-extensive with the corresponding discussion in our elementary text-books on analytics; the following chapter, however, on trigonometric curves is much more extensive and really supplies a fundamental want. The treatment of the logarithmic curve and the catenary presupposes familiarity with figures found in other books not generally accessible. Dipolar coordinates, both angular and vectorial, receive careful attention; the application of this method to the graphical solution of the simultaneous values of two angles defined by trigonometric equations is particularly interesting. The vectorial treatment of the lemniscate, cardioid and cassinian oval is somewhat heavy.

Nearly half of the book is devoted to a discussion of conical and parallel projection. The fundamental definitions are clear; the theorem that the projection of a plane figure can be determined by plane constructions is well explained. Each particular case is treated at great length, and the theorem regarding perspective triangles (theorem of Desargue) is shown to be the basis of most of the constructions. A circle is projected into the various conics, all the details of the construction being clearly considered. The articles on cross-ratio, while clear, are rather heavier; this method is becoming antiquated apart from purely theoretical uses. The harmonic case should have been made more prominent and the constructions for this fundamental case not regarded as a particular type of the anharmonic one. The subsequent constructions somewhat closely follow those given in Leudesdorf's translation of Cremona's "Projective Geometry," namely, homographic ranges and pencils, construction of conics from five elements, the theorems of Pascal and Brianchon with numerous applications to particular cases, and finally involution and polar theory. These later subjects have been treated too individually. One well grounded in the preceding theory and equipped with a proper notation needs no new instructions in applying it to any particular or even limiting case. An elementary resumé of the salient points of projective construction without all the machinery of a rigorous discussion is a desideratum, and this the authors have supplied.

*Assistant Professor of Mathematics, Cornell University, Ithaca, N. Y.

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A TEXT-BOOK OF PRACTICAL PHYSICS.—By William Watson, A. R. C. S., D. Sc. (Lond.), F. R. S. London, New York and Bombay: Longmans, Green & Co. Cloth; 5 x 8 ins.; pp. 626; 278 illustrations in the text, and 28 tables. $3, net.

This is a treatise on physical measurements, or experimental physics; no description of phenomena or laws is included, except occasionally as incident to the explanation of an experiment or a calculation. Both the arrangement of the text and its style are excellent. Specially commendable is the opening chapter, entitled "Methods Used in the Reduction and Discussion of the Results of Physical Measurements." An appendix giving hints on glass-blowing and some other manipulations is also worth noting.

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Nautical Charts.

Reviewed by GEORGE C. COMSTOCK.*

ALTITUDE, AZIMUTH AND GEOGRAPHICAL POSITION.—Comprising Graphical Tables for Finding the Altitude and Azimuth, the Position-Line, and the Variation of the Compass; and for Identifying Observed Celestial Bodies, and Finding the Course and Distance in Great Circle Sailing. By G. W. Littlehales, C. E., Hydrographic Engineer, U. S. Navy Department. Philadelphia, Pa.: J. B. Lippincott Co. Cloth; 13¾ × 23½ ins.; pp. 201; 368 plates, two on a page. $25.

This handsome and expensive volume is an attempt to bring within the grasp of the ordinary navigating officer those more recondite methods of his art, which, for their complete understanding, involve a considerable knowledge of mathematics and nautical astronomy. Great circle sailing, astronomical determinations of the compass error, Sumner's method for finding the position of a ship, all involve the solution of spherical triangles, and it is the function of the present work to substitute for the conventional logarithmic solution of these triangles the use of certain diagrams here published in great detail. In principle, the celestial sphere with its network of hour circles and parallels of declination is projected upon the plane of the observer's meridian, and upon the lines thus projected is superposed a system of polar co-ordinates having its origin at the center of the projection. The celestial pole and the observer's zenith fall at determinate points upon the circumference of the resulting figure, and the projected position of any celestial object, e. g., the sun, may be found and plotted by means of its declination and hour angle, as furnished by the almanac and the ship's chronometer. We come, now, to the essential element of Mr. Littlehales' volume: The plotted positions of pole, zenith, sun, furnish the projection of the astronomical triangle, and if this triangle be revolved in the plane of the projected figure, about the center of figure as a pole, through an angle equal to the complement of the observer's latitude, it will assume a new position in which the true altitude and azimuth of the celestial body above considered may be read directly from the same system of reference lines that originally served to plot its declination and hour angle. The spherical triangle is thereby solved, and the chief purpose of the volume is accomplished.

To obtain the requisite numerical accuracy it is evident that the projection must be on a large scale, and this is accomplished by breaking it up into a series of 368 overlapping charts, each representing the projection of only a small portion of the sky. The entire projection, in one piece and upon a smaller scale, is appended to the volume and serves as a key to indicate the special charts upon which fall in any given case the initially projected position of the sun and its corresponding position after the triangle has been revolved as above indicated. The superposed system of polar coordinates serves as a convenient mechanism for effecting this revolution, the radius vector of the projected body being the same on both charts, and the position angle of the body in the second chart being found from that in the first chart by adding to the latter the complement of the latitude.

It is apparent that for the actual solution of a spherical triangle, e. g., the determining of a course and distance in great circle sailing, or determining the position of a Sumner line from an observed altitude of sun or star, the key map and two charts are to be consulted; upon one of the latter a point is plotted, its coordinates read off, a number added to one of these, the corresponding point plotted in the second chart, from which the required quantities are then read.

As respects accuracy, the charts appear adequate to all demands of nautical practice; at least, the reviewer finds from a comparison of the author's illustrative examples with a logarithmic solution of the same data, errors of one and two minutes of arc in the azimuth and half a minute in the altitudes furnished by the diagrams. These quantities seem to be well within the limits of error permissible at sea. At a pinch, the key map alone may be made to serve useful purposes, one of which the author very justly points out and comments upon, viz.: The tyro who at sea seeks to use observations of stars will frequently be at a loss to identify the object whose altitude he has measured, and the same difficulty may easily befall an accomplished astronomer observing through clouds that obscure most of the sky. In such cases, the observed altitude and compass bearing of the object will furnish a speedy and sure indentification through the star's declination and hour angle that may be read from the key map.

The author estimates that through the use of his charts the labor of reducing an observation may be diminished to the extent of 50 or 60%, but to the reviewer this appears so largely a matter of computing skill vs. familiarity with the charts, that any numerical estimate must be subject to wide limits of uncertainty. The beginner will undoubtedly acquire a reasonable facility in the use of the charts much more quickly and easily than he could acquire a like facility in the ordinary logarithmic treatment of nautical problems, and from this point of view the work may be heartily commended to those deep-water yachtsmen who aspire to qualify themselves as navigators. The extent to which the book will be used and appreciated by the professional navigating officer time alone can tell, since here a considerable mass of unreasoning conservatism will need to be overcome.

It goes without saying that the methods here presented for use by the navigating officer are equally applicable by the engineer or surveyor, and under certain circumstances they may be found very convenient for such use. It is probable, however, that the great bulk and expense of the volume will prove a barrier to its general use for such purposes, save in those exceptional cases when astronomical determinations of moderate precision are a staple part of the book in hand.

In mechanical execution the volume is admirable, but the reviewer would have found it more manageable had it been half as long and twice as thick. The rather crowded lines of the charts are often difficult to follow even by daylight, and with the book placed upon a firm support. Under the less favorable conditions found on shipboard it appears probable that frequent errors in the use of the charts may arise from this source. It is, perhaps, considerations of this kind (undue crowding) that have induced the author to leave incomplete the charts adjacent to the celestial poles, and the user of the volume should early take note that observations of Polaris fall somewhat outside its competence.

A well-written introduction sets forth briefly but adequately the manner in which the charts are to be employed, and shows by example how the data furnished by the diagrams are to be translated into the required Sumner line drawn in position upon the navigating chart. In closing, the reviewer cannot refrain from expressing his appreciation of the enormous amount of most painstaking labor that must have been expended upon the projection of the hundred thousand lines, more or less, that constitute the substance of the diagrams.

*Director, The Washburn Observatory, University of Wisconsin, Madison, Wis.

Metal Working.

Reviewed by WILLIAM W. BIRD.*

PRACTICAL METAL TURNING.—A Handbook for Machinists, Technical Students and Amateurs. By Joseph G. Horner, A. M. I. Mech. E. New York: The Norman W. Henley Publishing Co. Cloth; 5¼ × 8¼ ins.; pp. 404; 488 illustrations in the text. $3.50.

MODERN MILLING MACHINES.—Their Design, Construction and Working. A Handbook for Practical Men and Engineering Students. By Joseph G. Horner, A. M. I. Mech. E. New York: The Norman W. Henley Publishing Co. London, England: Crosby, Lockwood & Son. Cloth; 5¾ × 9 ins.; pp. 304; two plates and 269 text illustrations. $4.

PUNCHES, DIES AND TOOLS FOR MANUFACTURING IN PRESSES.—By Joseph V. Woodworth, M. E. A Companion and Reference Volume to the Author's Elementary Work Entitled "Dies, Their Construction and Use for the Modern Working of Sheet Metals." New York: The Norman W. Henley Publishing Co. Cloth; 5¾ × 9¼ ins.; pp. 483; 702 illustrations in the text. $4.

TOOLS FOR MACHINISTS AND WOODWORKERS.—Including Modern Instruments of Measurement. By Joseph Horner, A. M. I. Mech. E. New York: The Norman W. Henley Publishing Co. Cloth; 5¼ × 8¼ ins.; pp. 340; 456 illustrations in the text. $3.50.

"Practical Metal Turning" is a handbook for machinists, technical students and amateurs and is devoted strictly to the subject. Lathe work in all its varied forms is discussed, its many tools and appliances are shown and described and the question of speeds and feeds for various tools and metals is well treated. A good deal of valuable information is given regarding the use of high-speed steel for lathe work. While nothing new or especially novel is found, the book as a whole is well arranged, the illustrations are good, and a copy is worth owning for those interested in this line of work.

It is doubtful if there is any other one branch of machine shop practice to which we owe more than we do to that branch of the work known as milling. Hundreds of operations are at the present time commercially possible only because of the milling machine. The appearance of "Modern Milling Machines" is therefore particularly timely. The author has endeavored to treat the subject, both in the text and by the illustrations, in such a manner as will make clear the essentials of the art, and to provide a book which will be useful to both the designer and the operator. That Mr. Horner has succeeded in doing this is the opinion of the reviewer, who believes that the skilled workman as well as the amateur will find much that is valuable and worth while and little of the usual padding. The chapter on Cutters contains many

*Professor of Mechanical Engineering and Director of the Washburn Shops, Worcester Polytechnic Institute, Worcester, Mass.

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valuable suggestions. Any one collecting a library of shop books should include this volume.

In "Punches, Dies and Tools for Manufacturing in Presses," the author has aimed to give to the practical man as much useful information as possible on the working of sheet metals, the design and construction of punches and dies and the manufacture of repetition parts and articles in presses. The book is a broader and more comprehensive view of the subject than that given in the author's previous work on "Dies, Their Construction and Use," and is therefore a valuable addition to the literature on this subject. While a greater part of the book is a mere collection of what has already been published in various papers, the book as a whole makes a good collection and should be owned by any one especially interested in this line of work, as there is probably no other one place where so much valuable data on this specialty can be found.

"Tools for Machinists and Woodworkers" was reviewed in these columns on Nov. 16, 1905, the only difference being a change in the title by substituting the work "Machinists" for "Engineers."

Lead.

Reviewed by BRADLEY STOUGHTON.*

LEAD SMELTING AND REFINING.—With Some Notes on Lead Mining. Edited by Walter Renton Ingalls. New York and London: The Engineering and Mining Journal. Cloth; 6 × 9½ ins.; pp. 327; 51 illustrations, partly in the text. $3.

This book is a reprint of various articles pertaining to the mining, smelting and refining of lead. Most of the articles have appeared in the "Engineering and Mining Journal" during the last three years, but some are from earlier issues and others are reprinted from the transactions of the American Institute of Mining Engineers. The author states:

> The articles comprised in this book relate to a variety of subjects which are of importance in the practical metallurgy of lead, and especially in connection with the desulphurization of galena, which is now accomplished by a new class of processes known as "Lime Roasting" processes. The successful introduction of these processes into the metallurgy of lead has been one of the most important features in the history of the latter during the last twenty-five years. Their development is so recent that they are not elsewhere treated in technical literature, outside of the pages of the periodicals and the transactions of engineering societies.

This method of compilation is one that has been followed with success before by the "Engineering and Mining Journal," notably in the case of "Pyritic Smelting," edited by the former editor, Mr. T. A. Richard. In each case it has resulted in placing in the hands of engineers a book covering a special subject concisely, and with sufficient thoroughness, brought up to date more completely than could be accomplished in almost any other way.

The present volume covers Lead Mining, Roast-Reaction Smelting, referring especially to the lead hearth process which has recently increased in importance; Sintering and Briquetting, Blast Furnace Smelting, Lime-Roasting of Galena, to which nearly one-third of the book is devoted giving information of the highest technical and scientific importance; Dust and Fume Recovery, a comparison of Rotary Blowers with Blowing Engines; Refining, and descriptions of new or important Smelting Works and Refineries.

Besides the distinguished editor of this book, who has personally contributed more than one-quarter of the text, there are several well-known practitioners and authors who have contributed to it, among whom we may mention especially R. D. O. Johnson, C. V. Petraeus and W. G. Waring on the mining of lead ores; Professor W. Borchers, who has ably discussed the technology of lime-roasting; A. Lotti, on a special method of smelting lead-copper ores; J. Parke Channing and H. W. Hixon, who discuss rotary blowers and blowing engines; Malvern W. Iles, who gives rare figures on the cost of smelting and refining; T. J. Greenway, on the preparation of fine ores for smelting; Arthur S. Dwight, on smelting and especially on mechanical feeding of silver-lead blast furnaces; A. Biernbaum, Thomas Huntington and Ferdinand Heberlein, on the lime roasting of galena, of which the two latter are the pioneer inventors; Titus Ulke and Anson G. Betts, on the electrolytic refining of lead, invented by the latter, and finally Professor O. Pufahl, who made a metallurgical visit to this country in 1905, describes eight smelting works and refineries.

Notwithstanding the number of different authors who have discussed the various questions, the whole book is very concise in its treatment, and there is an astonishingly small amount of duplication. The book is not a complete textbook of the subject of which it treats, but presupposes a knowledge on the part of the reader of the fundamental principles involved. For the use of practitioners and as a supplement to textbooks of the subject it is of great value.

*Adjunct Professor, Department of Metallurgy, Columbia University, New York City.

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APPENDIX.—Preliminary Hypotheses. Rectangular Members under Transverse Loading. T Beams, with Neutral Axis below the Bottom of the Slab. Members Subjected to Direct Compression. Hooped Columns. Regulations of the New York Building Code.

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Water Transportation.

OCEAN AND INLAND WATER TRANSPORTATION.—By Emory R. Johnson, Ph. D., Professor of Transportation and Commerce in the University of Pennsylvania, Member of the Isthmian Canal Commission, 1899 to 1904, Author of "American Railway Transportation." New York: D. Appleton & Co. Cloth; 5¼ × 7¾ ins.; pp. 395; folding plates and text illustrations. $1.50, net.

The economics of water transportation is one of the live questions of the day, and it is a subject on which most educated Americans have little accurate knowledge. In the current discussion as to the proposed subsidizing of the American Merchant Marine, for example, it is seldom one hears an accurate and intelligent statement of the actual condition of the ocean carrying trade. The business methods by which ocean shipping industry is carried on are unknown to American business men, outside the few actually engaged in foreign trade.

In the book before us, the author gives a clear, non-technical account of water transportation methods of the present day. Four-fifths of his space he devotes to ocean commerce and the remaining one-fifth to commerce on internal waterways. At a time when river and harbor appropriations are under current discussion, this latter portion of the book is of special interest.

The author favors the improvement of the larger rivers, such as the Hudson and the Columbia, and the 9-ft. slackwater navigation on the Ohio. Concerning the Mississippi, however, he remarks that its improvement presents an engineering problem of great difficulty. He thinks, however, that this problem may be solved and that the task of making the Mississippi a waterway of great commercial importance may yet be undertaken.

We believe the book is a useful one for the commercial courses of study now becoming popular in our institutions of learning and that it should be included in the reference libraries of engineering schools and engineering societies. The practicing engineer who meets problems in connection with the economics of water transportation will find in it up-to-date information obtainable only with great difficulty from other sources.

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Two German Text Books.

DER GRUNDBAU.—After Lectures Given in the Finnish Polytechnic Institute at Helsingfors by M. Strukel, Professor of Engineering. Second edition, enlarged. Helsingfors, Finland: Förlagsaktiebolaget Helios. Leipzig, Germany: A. Twietmeyer. Paper; 7¾ × 10¼ ins.; pp. 347; 118 illustrations in the text; atlas in separate binding, containing 36 plates. 18 marks; American price, $5.40.

This work has been enlarged nearly one-half in appearing in second edition. Its most notable feature is that more space is devoted to tools and apparatus than to foundation construction per se [220 pages out of 347]. The collection of illustrations in atlas form in a separate volume, made up of 36 two-page plates, facilitates the ample illustration of machinery and methods, of which opportunity full advantage is taken. The text is very compact, but generally nothing is lost thereby in the way of clearness or fullness. The fact is noted that some special kinds of foundation work, as caisson and deep well foundations for tall buildings, are not covered, nor are accessory problems, such as those of underpinning, considered. But this is no strong criticism, for a good and comprehensive book on foundation work is still a thing of the future.

DER BRUECKENBAU.—After Lectures Given in the Finnish Polytechnic Institute at Helsingfors by M. Strukel, Professor of Engineering. Atlas, Part II. Helsingfors, Finland: Förlagsaktiebolaget Helios. Leipzig, Germany: A. Twietmeyer. Paper; 7¾ × 10¼ ins.; 41 plates. 10 marks; American price, $3.

The first part of Prof. Strukel's Atlas of Bridge Construction dealt with timber and metal bridges, excluding movable bridges. The present (second) volume completes the Atlas by covering the subject of masonry bridges and movable bridges. It consists of 41 two-page plates, containing drawings (and a few halftone views) of completed structures and details. About 40 pages of text form a table of contents, in which the subject of every figure is named, and short descriptive notes of the more important structures are given. Twelve of the plates, only, are devoted to movable bridges, the remaining 29 to masonry (including concrete and reinforced-concrete) bridges. Arch centering alone covers no less than eight plates, with a hundred or more separate figures. There is a number of American examples among the structures shown, for instance, the Rock Creek arch bridge in Washington, and the ferry bridge at the Duluth-Superior harbor entrance.

MECHANICAL ENGINEERING MATERIALS.—Their Properties and Treatment in Construction. By Edward C. R. Marks, M. Inst. M. E., Assoc. M. Inst. C. E., Author of "The Construction of Cranes and Other Lifting Machinery," etc. New and enlarged edition. Manchester and London, England: The Technical Publishing Co., Ltd. New York: D. Van Nostrand Co. Cloth; 4⅜ × 7¼ ins.; pp. 98; 38 illustrations in the text. 2s. 6d., net; American price, 60 cts.

The one criticism of this book is that the author has selected a too pretentious title. As "The Metals and Alloys Used in Mechanical Engineering" it would be a very useful little volume of information on methods of manufacture, properties and tests of steel, iron, copper and the various copper, manganese, tin and aluminum alloys used, for the most part, in machinery.

BULLETINS, U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ × 9 ins.

No. 307: Manual of Topographic Methods. By Henry Gannett. Pp. 88; eight plates and four text figures.

This paper was first published in 1893 as Monograph XXII. of the U. S. Geological Survey. In the introduction the author says:

> The object of this manual is a description of the topographic work, instruments, and methods of the U. S. Geological Survey, primarily for the information of the men engaged in this work. It is not intended to be an elementary treatise of surveying, as it presupposes a knowledge of the application of mathematics to surveying equivalent to that obtained in our professional schools. Neither is it intended to be a general treatise on topographic work, although it may, to a certain extent, supply the need of such a work.

In spite of the last sentence this small book might be very well used as a manual for any extensive topographic work, such as is now being conducted by the various State surveys, and on such large works as the surveys for the new water supply of New York City. As a supplementary text-book it would be especially valuable in an advanced college course in geodetic surveying, as it gives in compact form the various kinds of astronomic determination of position and descriptions of the more important instruments used in topographic triangulation, together with the results of experience of the Geological Survey in the matter of party personnel and methods of work.

INVENTORS AT WORK.—With Chapters on Discovery. By George Iles, Author of "Flame, Electricity and the Camera." New York: Doubleday, Page & Co. Cloth; 5¾ × 9¼ ins.; pp. xxii. + 503; numerous illustrations. $2.50, net.

Instead of a series of biographical sketches, or narratives of inventors' work, which one might expect in a book headed "Inventors at Work," the text of Mr. Iles' volume gives something totally different. But precisely what it gives can hardly be stated. Generally speaking, the book is a very superficial but also very inclusive collection of references to tools, devices, structures and details produced by human handicraft; these are abundantly illustrated. Apparently, the general purpose is to show or suggest the bearing of various general physical principles upon, or the importance of several elementary factors in, the improvement of material devices and the advance of scientific thought. Thus, a large part of the book, about one-half, is occupied by a series of chapters on Form, Size, and Properties, which are factors in improvement of devices; and there follow chapters on Measurement, Nature as a Teacher, Observation, Experiment, Simplification, Theorizing, which are factors in the advance of thought and in discovery on invention. But this general characterization is at best incomplete and inaccurate. The most direct comment that we can pass on the book is that it will prove good stimulating reading to a boy; it will direct his attention to certain physical characteristics of efficiency of various things, and tell him about many devices and constructions with which he has not yet made acquaintance.

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Two Elementary Books on Electricity.

Reviewed by HENRY H. NORRIS.*

ELECTRICAL ENGINEERING.—An Elementary Text-Book. By E. Rosenberg, Chief Electrical Engineer at Messrs. Körting Bros., Hanover. Translated by W. W. Haldane Gee, A. M. I. E. E., Professor of Applied Physics at the Municipal School of Technology, Manchester, and Carl Kinsbrunner, Lecturer on Electrical Engineering at the Municipal School of Technology, Manchester. Revised and brought down to date for the American market by Edward B. Raymond, B. S., Assoc. M. Am. Inst. E. E. New York: John Wiley & Sons. Cloth; 5¾ x 9 ins.; pp. 347; 333 illustrations in the text. $2, net.

PRECIS D'ELECTRICITE.—By Paul Niewenglowski. In "Encyclopédie des Travaux Publics," Begun by M.-C. Lechalas. Paris, France: Gauthier-Villars. Paper; 6½ x 10 ins.; pp. 200; 64 illustrations in the text. 6 francs; American price, $1.80.

Rosenberg's book originated in a course of lectures delivered to electrical artisans. The treatment of the subject is intended primarily to be practical and interesting. In translating the work into English, Messrs. Gee and Kinzbrunner introduced illustrations from British practice without modifying the order and arrangement of the material. Mr. E. B. Raymond has amplified the text and adapted it to American readers. For a small work it has gone through an unusual number of hands, which is evidence that the publishers have considered it worth the large expense of translation and revision. Of the four names that appear on the title page two are of men in responsible charge of large manufacturing plants; the others are teachers of wide reputation.

The English edition was reviewed in these columns at the time of publication (Aug. 20, 1903) and a brief statement of the purpose and scope of the original work will suffice here. The author aimed to describe in concise form and in simple non-mathematical language the important applications of the electric current. The underlying principles were stated and briefly illustrated in an easy conversational style, the evident attempt being to write as one would have spoken in addressing his audience in person. The scope of the book covers the construction and operation of direct and alternating current generators and motors, electric lighting and power transmission. These topics are discussed in a fairly logical order, from the standpoint of the practical engineer and mechanic, and a large amount of accurate and valuable information is given. The title of the book leads one to expect a general perspective view of electrical engineering practice. This it does not give, but rather goes into the details of a large number of selected subjects.

The American reviser has made very few changes in the original material, except in slightly rearranging the order in a few places and in substituing cuts of modern machines for those of older types. He has added a number of paragraphs amplifying the alternating current and other sections, particularly those dealing with generators, motors and transformers. The additions are of a more theoretical nature than the original, requiring some knowledge of trigonometry, geometry and algebra, but avoiding entirely the use of the calculus. There are also a number of new curves, showing graphically the performance of various machines. The revision has improved the work as a text-book for schools and has not made it inaccessible to the general reader, as he can pass over these pages without losing the general plan.

The book aims to meet the need for a general and comprehensive but brief summary of electrical practice. It covers the same ground as "Electrical Engineering," by Slingo and Brooker, and is one of the very few books in which the attempt is made to do so much in a small space. The revision insures a wider reading and the price is very reasonable, placing it within reach of mechanics, draftsmen and students. The general make-up of the volume shows plainly the way in which it has been built; in fact, the "patching" is quite evident. As an example, pages 169 to 175 are copied verbatim from Bulletin No. 4,377 of the General Electric Co., this material being different in form and purpose from the bulk of the text. Many of the cuts are crude and to the text additions are apparently made in such a way as to preserve as many of the original plates as possible. It is hoped that in the next edition the entire work will be rewritten, so that a uniformity of literary style and of mechanical execution may result. In spite of the mechanical faults mentioned the book is a good one and will be found useful to several classes of readers.

*Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.

An elementary book of an entirely different nature from that above reviewed is the mathematical treatise of M. Niewenglowski. As the title indicates, it aims to give an exact statement of the laws underlying electrical phenomena. The subject is studied from the physical and mathematical side with only incidental reference to the applications. It is written in a simple informal style and its compactness and brevity renders it convenient for reference.

The book is divided into two parts, one covering the elementary laws and experiments, the other dealing with the accepted theories of electrical and magnetic phenomena. In Part I. the author explains clearly the laws of electric currents, electromagnetism, induction, magnetism, electrostatics, measurements and units. The explanations will present no difficulties to any one possessed of an elementary reading knowledge of French and a working acquaintance with the calculus and physics. It is not easy reading for the beginner, but will be appreciated by the practical though technically trained engineer who wishes to review the fundamentals of his profession. The treatise is evidently intended for this class of men, as it forms a part of a series, the Encyclopédie des Travaux Publics, which contains monographs upon many subjects of interest to civil engineers and others. Part II. is of less general interest and requires more extended scientific preparation. The mathematical theory of electrostatics receives careful attention and is followed by some analogies from other branches of physics. Alternating currents are briefly mentioned and the theories of electromagnetism and of induction are fully stated.

As a whole, M. Niewenglowski's book presents in very compact form a compilation of accepted electrical theory. It is made up of a series of numbered paragraphs, suitable for recitations by advanced classes in electrical physics, presumably of graduate students. The whole is logically divided into chapters and topics, and it will form a good theoretical "tonic" for the practicing engineer whose work often leads him away from theory and makes him forgetful of the scientific basis of his success.

CONCRETE FACTORIES.—An illustrated review of the principles of construction of reinforced concrete buildings, including reports of the Sub-Committee on Tests, the U. S. Geological Survey and the French Rules on Reinforced Concrete. Compiled by Robert W. Lesley, Assoc. Am. Soc. C. E. Published for the Cement Age Co., by Bruce & Banning, New York. Boards; 6½ x 10 ins.; pp. 152; numerous illustrations. $1.

This is a compilation of various articles which have appeared from time to time in "Cement Age." It contains the proposed scheme of tests to be used by the two large committees named in the title in the investigation of the nature of cements and concretes, together with the report of the board appointed by the French government on the same subject. The article on Concrete Factories consists principally of photographic illustrations of the construction of such buildings with brief descriptive notes.

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No. 62: Census of Manufactures: 1905. Glass and Clay Products. Pp. 107.
No. 65: Census of Manufactures: 1905. Coke. Pp. 57; illustrated.

BULLETINS, U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ × 9 ins.
No. 306: Rate of Recession of Niagara Falls. By G. K. Gilbert. Accompanied by a Report on the Survey of the Crest, by W. Carvel Hall. Pp. 31; 11 plates and 8 text figures in the text.
No. 310: Results of Primary Triangulation and Primary Traverse. Fiscal Year 1905-6. By Samuel S. Gannett. Pp. 248; one folding plate.

THE CANADA YEAR BOOK 1905.—Second Series. (Archibald Blue, Chief Officer, Census and Statistics Office.) Ottawa, Ont.: Pub. Doc. Paper; 5¾ × 8¾ ins.; pp. xii. + 351.

COLORADO COLLEGE PUBLICATION.—Engineering Series, Vol. I., Nos. 1, 2 (General Series No. 24). Containing: 1. The Fusibility and Fluidity of Titaniferous Silicates, by L. C. Lennox and Chas. N. Cox, Jr.; 2. The Design of a Low-Tension Switchboard, by V. T. Brigham; being Bachelor's Theses Submitted to the Faculty of Colorado College, June, 1906. Colorado Springs, Colo.: The College (Florian Cajori, Managing Editor). Paper; 6 × 9 ins.; pp. 34; several illustrations in the text and five plates.

CONCRETE AND REINFORCED CONCRETE CONSTRUCTION.—By Homer A. Reid, Assoc. M. Am. Soc. C. E., Assistant Engineer, Bureau of Buildings, New York City. New York: The Myron C. Clark Publishing Co. Cloth; 6 × 9¼ ins.; pp. 884; 715 illustrations in the text. $5, net.

THE CONCRETE REVIEW.—Issued by the Association of American Portland Cement Manufacturers. Vol. I., No. 1, Feb. 1, 1907. 9 × 12 ins.; pp. 4; illustrated.

DIE DAMPFLOKOMOTIVEN DER GEGENWART.—A Manual for Locomotive Builders, Railway Operating Officials and Students of Mechanical Engineering. By Robert Garbe. Berlin, Germany: Julius Springer. Cloth; 7½ × 10¾ ins.; pp. 500; 388 illustrations in the text and 24 plates.

THE DANGERS OF MUNICIPAL OWNERSHIP.—By Robert P. Porter, Director of Eleventh U. S. Census, Author of "Commerce and Industry of Japan," "Industrial Cuba," etc. New York: The Century Co. Cloth; 5½ × 8½ ins.; pp. 356. $1.80; postage, 20 cts.

ELECTRIC AND MAGNETIC MEASUREMENTS AND MEASURING INSTRUMENTS.—By Frank W. Roller, M. Am. Inst. E. E. New York: McGraw Publishing Co. Cloth; 6 × 9¼ ins.; pp. 398; 312 illustrations in the text. $3.50, net.

FOWLER'S MECHANICAL ENGINEER'S POCKET BOOK, 1907.—Edited by William H. Fowler, M. Inst. C. E., M. I. Mech. E. Manchester, England: Scientific Publishing Co. Leatherette; 3¾ × 6¼ ins.; pp. 542; illustrated. Leatherette, 1s. 9d. American price, 75 cts.

GEOLOGIC ATLAS OF THE UNITED STATES.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 18½ × 21¾ ins.
No. 142: Cloud Peak—Fort McKinley Folio. Wyoming. Pp. 16; 10 plates and 5 text figures.

MAINTENANCE OF PAVEMENTS AND ADMINSTRATION OF STREETS IN THE CITY OF N. Y.—A Report to the Merchants' Association of New York by its Committee on City Conditions. December, 1906. New York: The Merchants' Association (S. C. Mead, Secy.) Paper; 6 × 8¾ ins.; pp. 38.

NEW YORK STATE DEPARTMENT OF LABOR.—P. Tecumseh Sherman, Commissioner. Reports of Commissioner of Labor, and Bureaus of Factory Inspection, Mediation and Arbitration, and Labor Statistics Albany, N. Y.: Pub. Doc. 5¾ × 9 ins.; pp. 280, 301, 423, and clxxxix. + 810, respectively.

NORTHERN NEW JERSEY CONSIDERED AS PART OF THE PORT OF NEW YORK.—Report of the Interurban Committee of the Newark Board of Trade, December, 1906. (J. C. Dana, Chairman.) Paper; 5½ × 8½ ins.; pp. 32; one folding plate.

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